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Wilson Mutagwaba, Rosemary Mwaipopo-Ako and
Anderson Mlaki

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1.0 INTRODUCTION

Small-scale artisanal mining in Tanzania involving minerals such as gold, gemstones, salt, kaolin, building and construction materials can be traced back to the colonial period and has gone through different transformations over time. It has significant contribution to the National economy and as a source of livelihood for the rural population.

This sector has been a significant employer as proven by a number of studies (Lwakatare 1993, Chachage 1995, TANDISCOVERY 1996). Being largely a labour intensive operation, it has a greater impact on employment than the large scale mines, although the actual population estimates of those involved is affected by the miners' nomadic working habits, social organizations and the politics involved. Lwakatare (1993) estimated artisanal mining to involve 280,000 or more miners on full-time or part time basis. About 3200 were also estimated to be formally employed in mining salt, kaolin, coal, gold and other minerals in the country. Chachage, (1995) notes that "officially, there were 1440 small scale claim holders and 480 prospecting certificate holders in 1993. He further adds that at a very conservative estimate of 10,000 people per site, it is possible that there are about 900,000 people involved in small scale mining and auxiliary activities". While the most recent study conducted by TANDISCOVERY Ltd. (1996) contends that more than "555,000 people are directly involved in mining activities around the country, some of these are full time miners while others engage in both mining and other economic activities, especially fanning." In addition, a number of people are involved in the delivery of social services, e.g., food supply, health, personal services like recreation and entertainment. These people form a significant percentage of the mining communities whose employment is actually created in response to the development of these artisanal mining activities.

Artisanal mining has also been discussed in relation to the significant incomes it generates to certain population groups. Although it may not be realistic to establish a fixed amount of income for such activities, estimates on incomes indicate that some participants earn incomes that are more than the current government minimum salary of Tshs 30.0007= per month (about $50). For example, according to a study done by TANDISCOVERY (1996), monthly incomes are estimated as follows, the Claim owner in reef gold mining areas gets

about $730.2, pit owner $420.0, mine workers groups (5 people) $858.8 or $171.76 per individual miner. This is about 3.4 times more than the minimum salary.

The sector is however plagued by various factors which limit its operational and productive capacity to become a reliable source of livelihood for the entire population involved, despite its attractive potential. Gross inequalities in having access to mining rights, distribution of income, coupled with poor technical know-how, inadequate technology and thus low productivity and other constraints have trapped most of its population in poverty. Moreover, addressing artisanal mining not as a mining problem but rather as a poverty issue requires a comprehensive approach, which necessitates a clear comprehension of the poverty in question. According to Cooksey (1995), an approach which sees "poverty essentially in terms of inadequate income, consumption or employment opportunities is a poor basis for explaining poverty in terms of socio-economic relations" (op. cit. 1995:73). Likewise, regarding the disfunctioning of a system simply in terms of physical or material inadequacies is to claim, in other words, that solutions basically lie in the provision of such factors.

For example, Priester *et al.*, (1993), explain the vicious circle of small scale mining as basically caused by lack of training, finance and equipment which in turn generate other negative processes like low efficiency, low production, low wages, poor working conditions and others. However, these inadequacies may not be fully realized not only because of the many inadequacies in the process itself, but also from the regulations and practices that attempt to manage it.

This nexus is important since it admits the fact that one cannot visualize poverty in relation to artisanal mining essentially as an instance of inadequacy in physical or material factors (in this case poor technology or working tools), without having an initial understanding of the socio-structural relationships and transformations taking place within the whole sector and between it and related ones. Being an economic activity, it involves the interaction of various levels and types of institutions and inter-relationships between various population groups each with a specific role in its development, and different expectations. It is thus important to explore these various complementary levels and assess equity issues and factors leading to poverty despite the seemingly high income levels gained by some individual miners.

Technological considerations feature significantly because of their direct implication on output levels, safety and environmental aspects, which in turn determine the continued well-being of the populations involved in artisanal mining. As underscored in this contention, "measures to improve working conditions and output need to focus on the quality of work in artisanal mining rather than just the quantity. Any increase in the quality of human effort put to artisanal mining will be more than matched by the quantity, quality and value of output due to more efficient production and higher value added at the primary processing stage prior to sale" (Jennings 1993).

2.0 RESEARCH METHODOLOGY

2.1 Research Objective

This study set out to explore the following broad objectives:

- Identification of technological problems facing artisanal mining; which includes current techniques and equipment used in mining and beneficiation, geological information, appropriate mining and processing tools, existing capacity for fabrication of working tools, strategies for improving miners' knowledge and skills.

- Exploration of socio-economic aspects related to artisanal mining and their inter relationship with technological issues identified with the above mentioned issues.

2.2 The Research Problem and Questions

In identifying the research problem in relation to poverty alleviation, the choice to focus on artisanal mining activities within the Mining Industry was based on several considerations regarded as essential in understanding poverty. These reasons include among others, the following:

- There is usually a misconception amongst many people, that those involved in mining activities make a lot of money despite the risks involved. This belief is among many reasons that attract a large number of people to such activities;
- Artisanal mining activities involve small-scale production processes which attract/absorb labour that is otherwise disadvantaged, unemployed, vulnerable, etc. In other words, these activities generate employment mainly to the rural majority;
- The activities are wide spread in the country and thus offer areas where production capacity can be expanded to improve the well being of the participants if technological application is improved;
- Artisanal mining offers the conditions to study how the organization of labour can determine access to benefits of production even with improved technological application and hence inequality and poverty.

The research problem focuses on the fact that the lack of appropriate mining and processing technology coupled with the unavailability of even the basic infrastructural facilities, lack of information, and related socio-economic constraints, have resulted into unproductive mining practices and negative effects to the environment. This problem is accentuated by the failure of institutional and organizational infrastructure to give a sound basis for the development or investment of technology in artisanal mining.

2.3 The Study Area

This study was conducted in the following mining areas, Mgusu (gold) in Geita, Rwamagaza (gold) in Geita, Mabuki (diamonds) in Misungwi, Merelani (tanzanite) in Arusha and Matombo -Ng'ong'olo (ruby) in Morogoro.

The criteria for the selection of these areas included; (i) Representative samples in terms of the minerals in which most artisanal miners are involved. Available documented statistics state that most artisanal/small scale miners in Tanzania are engaged in gold and precious stone production, (ii) Mineral variety, hence the choice of gold, diamonds, ruby and Tanzanite. (iii) Accessibility: During the time of this study, certain areas were inaccessible because of government restrictions, e.g., Bulyanhulu and Tunduru. (iv) Budget restrictions: consideration had to be made on proximity and financial limitations.

(a) Mgusu Gold Mining Area

The Mgusu mining village which is located 25km. west of Geita town, Mwanza Region was established in 1988 following artisanal miners discovery of gold in the Saragura - Mgusu Hill area. The mining area is located within two claims (CT 36979 and CT 36980) registered under Mr. J. Chipaka who started mining in an old exploration trench with nearly 200 miners. By 1989/90 the population at the newly established Mgusu mining village had grown to between 8,000-10,000. The population actually engaged in mining is estimated to be between 1500 and 2000 while the rest include those engaged in agriculture, trade and to a small extent local government employees (teachers, extension workers and medical staff). Most basic services are available at the settlement, namely, 2 primary schools, churches/a mosque, dispensary, market place, bars, restaurants and guest houses.

The occurrence of gold at Mgusu is found in small quartz veins or stock-work in metamorphosed and highly weathered and kaolinized layolite porphyry and tuff. Overlying the porphyry, are the folded and fractured Banded Iron Formations (BIF). Fracturing following the bedding of BIF units appears to have been important in the localization of gold mineralization at Mgusu.

(b) Rwamagaza Mining Area

Rwamagaza mining area is located in Katoro ward, Geita District. Geologically, it lies within the Rwamagaza greenstone belt south of the Geita belt. Buckreef mine, formerly run by STAMICO and now by East African Mines Ltd., a private company, lies in the same belt. Because of intense laterization of the greenstone rocks, there are few outcrops of the bedrock., which are of massive basic volcanic rocks, with some thin beds of tuff. The distinctive feature of Rwamagaza greenstone belts is the occurrence of gold nuggets in the rubble at the base of the laterite (MWEM, 1991). Since the gold is not of alluvial origin it is thought to have been formed through processes of supergene enrichment. It is this distinctive feature that makes Rwamagaza attractive to artisanal and small-scale mining. Active artisanal mining activities in the area can be traced back to 1974. Other artisanal mining areas within the belt include Buziba and Nyamtondo.

(c) **Mabuki Diamond Mining Area**

Only one diamond mining site, namely Mabuki located in Misungwi district, Mwanza Region, was visited. Mabuki is located 62km. South of Mwanza town and to the North of the famous Williamson Diamond Mine at Mwadui in Shinyanga Region. There are over 300 known kimberlite pipes in Tanzania of which only 20% are diamondiferous. Of these,

nearly half lie within 200 km from Shinyanga (MWEM, 1991). The diamondiferous ones show a North-South trend from Mwanza to Shinyanga. Mabuki lies within this zone.

(d) Mercian! Tanzanite Mining Area

Tanzanite, which is a sapphire blue zoisit
e, first made its way to the international market in 1967. The name Tanzanite was proposed by Henry Platt, the Vice President of Tiffany & Co., a world re-known gemstone dealing company, because of its spectacular trichroism and peculiarity, (Malisa, 1987).

The Tanzanite mining site of Merelani lies in the flanks of Lelatema mountains 20 km South East of Kilimanjaro International Airport. It is believed that the site was first spotted by the semi-Nomadic Maasai who later showed it to prospectors and, artisanal mining was carried out. The area was taken over by the government in 1971 and put under operations of Tanzania Gemstone Industries Ltd. (TGI) a subsidiary of the National Development Corporation (NDC) then and later of STAMICO. TGI still operates in the area in a joint venture partnership with a foreign company, Graphtan Ltd, a subsidiary of SAMAX Resources, a British company, in one of the four blocks (A, B, C, D) allocated by the government. Small-scale miners operate in blocks B and D, Kilimanjaro Mines block A and TGI/Graphtan block C.

Blocks B and D are subdivided into small plots which are then located to license Holders. Claims in block D are not equal in sizes because they were reallocated by taking into consideration how much one had invested in the area. This practical solution was sought by the Government following ownership conflicts between AREMA members and other miners outside AREMA membership. On the other hand, block B which was allocated later by the government has claims of equal sizes measuring 50m x 50m. The average size of most pits are 2mx3m. Block D pits, which have been mined over a long period are very deep thus forcing most miners to move to block B. Deep pits have attained a depth of about 150m thus causing technical and logistic problems to miners.

(e) Matombo - Ng'ongolo Ruby Mining Area

Ng'ongolo is located 20 km east of Matombo town which is 70 km from Morogoro town. The ruby mining areas in Morogoro include Matombo, whose most active areas are, Ng'ongolo, Mwalazi, Gumba and Nyamuhui; Lukande in Mahenge; and Kitonga, Nzelezi, Epanko and Ruaha - Kituti. These areas have been experiencing peaks in mining activity since 1989 which has currently subsided significantly because of the 'Tunduru rush' although it is believed that after the Thai's had left Lukande for Tunduru, about 100 people illegally rushed into these areas. Regional based data on applications for small scale mining licenses are as follows: 1989 - 99; 1990 - 87; 1991 - 227; 1992 - 186; 1993 - 148; 1994 - 105; 1995 - 24; and, by February 1996, there were only 2 applications. Most of the miners are local people and an estimated 1/4 come from other regions in Tanzania. Consequently, the surrounding villages or peri- urban settlements have benefited economically from artisanal/small scale mining.

2.4 The Study Population

The study population was selected through purposive sampling. It comprised all categories of people engaged in mining and mining settlement activities, selected informants including local authorities, government officials and institutions related in one way or the other to artisanal mining sector, and women. Although the majority of miners are men, there is also a class of women who are active in mining. Some are claim owners and sponsors of pit owners. Also a large number of traders in food stuffs and other commodities are women. There were cases of children being employed in mines but the study primarily targeted men and women in the classification of the poor. Another more detailed study on the plight of children in artisanal mining should be conducted.

2.5 Data Collection Techniques

The techniques adopted by this study for gathering data were as follows:-

(a) Literature Review: A review of existing documented literature on Poverty, Technology and Artisanal Mining was a continuous activity during the study.

(b) Field survey: Field work survey was conducted on the selected areas and the following techniques for gathering information were employed: Focus Group Discussions, In-depth interviews and Participant observation and discussion with strategic informants. The objective was to collect qualitative data through participatory and problem solving oriented approaches.

(c) Exploring existing local capacity for design, fabrication and manufacturing of appropriate working tools.

(d) Conducting a survey to establish methods and tools used in other areas outside Tanzania that are involved in artisanal mining.

2.6 Hypotheses

The hypotheses postulated for the study were as follows:

(1) There is a direct relationship between the application of technology and increased productivity.

(2) The nature of the social and economic environment has a bearing on the decision for technological application in the production process.

(3) The organization of production determines the nature of the miners environment and hence their opportunities and constraints.

(4) The lack of information and adequate knowledge on mining technology influences the level of production and risks involved.

(5) Absence of a coherent institutional framework concerned with mining affects the work environment of miners and hence their earnings.

3. 0 LITERATURE REVIEW

There is currently no consensus on the definition of artisanal or small-scale mining, and what constitutes a small scale mine is still a controversial issue amongst those who are involved in the mining industry. The lack of consensus as echoed by several writers (Quashie, 1991, Priester et al., 1993, Taupitz, 1994), is due to variations from country to country. For example, a small-scale mine in South Africa might be categorized as medium scale in Tanzania. Attempts to give a definition have been based on different aspects, including, investment costs, labour requirements, ore production rates, size of concessions, amount of reserves, annual sales, or any combination of the above. For example, the United Nations definition sets the upper boundary of production as 50,000 tonnes/annum from open cast operations, (Barnea, 1978). However, this categorization has problems in that the amount of ore required to recover, say, a tonne of mineral A is not necessarily the same for mineral B. Quashie (1991), suggests that the classification of precious metal mines, should be based on amounts of minerals produced, e.g. ounces of gold per annum rather than on tonnes of run-of-mine ore per annum. Another definition is based on the cost of investment and sets the upper limit for small-scale mining below the lower limit of project financing by commercial financial institutions or mining finance houses, i.e. $3-5 million capital requirements, (Taupitz, 1993).

The World Bank in its document "Tanzania Mining Sector Review" acknowledges the problems of definition that arise from the use of the term "small-scale" mining (WB, 1990). It categorizes the activities as varying from what might be termed "subsistence mining" performed by an individual or family recovering minerals to support their basic rural life-style to small-scale, essentially, non-mechanized mining.

In the Tanzanian context, the definition of small-scale mining is provided in the "Small-scale Mining Policy" (1983) as having the following characteristics:

- Labour intensive with low initial capital (below TShs.500,000/=)
- Does not require skilled labour and/or specialized technology
- The gestation period from exploration to production is short.

This study adopts World Bank's term "subsistence mining" and the SADC Mining unit term "micro-scale mining" to refer to those activities carried out by individuals, families, and/or adhoc groups (some forms of cooperatives) of indigenous people, the majority of which have no technical expertise and lack adequate working tools but adapt the trade through practical experience. Some local researchers also attach production estimates to the definition of artisanal mining. For example, Ngonyani (1993) describes it as "mining or treating ore at a maximum rate of 4 tones/day by using locally fabricated tools", while Mutagwaba et al (1993) classifies artisanal mining as small operations processing not more than 10 tonnes /day of ore.

The use of the term "artisanal mining" is also subject to a number of criticisms particularly when related to historical conceptions of artisans as craftsmen who maintain close

relationships with their means and tools of production. The Longman Dictionary of Contemporary English (1990) defines an artisan as someone who does skilled work with his hands, a craftsman, a person who is skilled in his craft. The categorization of such miners as artisans thus stems from the fact that over time, mining and mineral processing have been done using basic skills and technology developed within the trade, such as, the excavation of pits as deep as 150m, devising support mechanisms, hoisting material to surface, fabricating mining and processing tools, by a population which is more or less dependent on the trade.

Initial negative conceptualisations of artisanal mining as a misnomer to mineral sector development are gradually being moderated by the increasing concern to alleviate poverty and improve living standards through sustainable growth and investment in the people (WB 1995). Part of this includes strategies for the promotion of labour intensive activities, a category under which artisanal mining falls. This study seeks to find out how the poor are identified in this sector and the appropriate measures taken to address such poverty.

Two basic approaches for intervention can be discerned. The first conceives of the poor as passive and the target for poverty alleviation, a mentality which Beck (1994) argues, "is the language of bureaucratic planning, with 'targets', 'aims' and recipients ready to be 'pushed', 'raised', accept delivery and to be attended to. The poor have become statistics with which statisticians can play and experiment... This pre-occupation with measurement fits well into a system where policy is created by a centralised state and then imposed on the poor 'from above' in order to shunt them above the poverty line" (Beck 1994 in E & U 1995). Thus, often, researchers and policy makers adhocly identify solutions for artisanal mining which do not include the miners own interpretations of the problems facing them (Mchaina et al 1987, Nanyaro 1992). This may hinder the development of appropriate solutions for addressing the actors within the sector.

Artisanal mining in Tanzania has also been conceptualized as a response by people to handle poverty. Since it operates informally, and outside the government structured administrative and institutional framework., it has attracted many people. It also requires neither large investment nor sophisticated equipment, and has considerably more job creation potential than mechanized mining because it is labour intensive and attracts unskilled labour. The miners are often blamed as the sources of problems which arise in this sector. Often their organizational problems and solutions are given precedence in administrative processes over technical deficiencies which include, the absence or low mechanization; low safety standards; poorly trained personnel; deficiencies in planning for mining and processing activities, hence low productivity; poor remuneration; lack of capital, seasonal mining and sometimes operating without concession rights (Priester et al 1993). Productive capacity is thus greatly influenced by low skills and low technological capacity, in addition to other factors which affect the share of proceeds.

3.1 Small-Scale Mining technology: A Historical Perspective

The first known formal mine in Tanzania was a small-scale gold mine opened in Sekenke in 1909. The introduction of mine mechanization was a result of the enactment of a new mining law by the British Administration in 1921 which led to the intensification of prospecting activities and resulted in the opening of the first mechanized small-scale gold mine in Musoma area in 1928. Although these earlier operations are referred to as small-scale mining operations, they do not fall within our definition of artisanal mining. They were small in terms of scale of operations but formally organized and although they were not at current scale, they were properly supervised through the "Area Mines Inspectorate" and the mine wardens. As such, despite the rudimentary technology, most activities were carried out within the set mining regulations.

In post independent Tanzania, there is no evidence of efforts to introduce technology in artisanal mining prior to 1980. In 1983, the Government published a policy paper on small-scale mining with the vision of transforming the sub-sector into more organized operations. Although the outlook of most developing countries in developing a mining sector was geared towards large scale and sophisticated mines that could solve all their economic problems and small-scale and artisanal mining operations were conceptualized as a misnomer for mineral sector development, in 1985 the Government through the then Ministry of Water, Energy and Minerals imported three mobile mineral processing plants, two for gold and one for tin. These were to assist the miners through provision of centralized processing services. The three plants were located at Buziba in Geita District, Kasanga in Chunya District and Kyerwa in Karagwe District. Despite the good intentions, the lack of a feasibility study for the project, poor coordination and inadequate financial resources, led to complete failure of the project. The Government is now in the process of selling-off these plants that have been rotting in the bush since 1985. In 1990, the Lupa Gold Mine, a subsidiary of STAMICO, running a small-scale alluvial gold mining operation introduced an advanced sluice box from Zimbabwe, also known as "Bambazonke". Despite its success at the plant, the technology was never disseminated to neighbouring artisanal mining operations. In 1993, the Institute of Production Innovation (IPI) of the University of Dar-es-Salaam designed and successfully tested in the field an amalgamation retort for the safe use of mercury. However, the lack of technical knowledge coupled with the suspicious nature of artisanal miners have made acceptance of the retort almost impossible. The liberalization of mining activities in 1989 have also seen efforts from the private sector to provide technological improvements to these operations. IPI has launched a project to design and fabricate small-scale mining equipment. Todate, a batch-ballmill has been produced and tested in the field. A local company, DEMCO, with its small-scale gold mining operations in Chunya, provides processing services to miners who pay in different modes including exchange of tailings. The tailings are later reprocessed by the company to recover the remaining finer gold through cyanidation. Access to technological improvements by artisanal miners have been frustrated by, among other things, the Government policy to limit these activities to Tanzanians only. As a result, acquisition of foreign capital and technology through joint venture partnership has been almost impossible.

3.2 Poverty and Technology

Poverty is generally characterized by low incomes and the inability to satisfy basic needs. It also entails exclusion of individuals and families from the productive process, from integration into the larger society and from access to opportunities. The roots of poverty can be found in the unequal distribution of resources and opportunities, socially determined access to the benefits of development and the inability of governments to compensate for social imbalances. Often people are forced by poor living conditions to engage in various productive enterprises regardless of the risks involved, or the strenuos conditions for production so as to attain basic requirements and to survive. Attempts to reduce poverty should thus also involve provision of basic services such as health and education. Education, skills and technology improve not only the efficiency in production but also the life styles of the producers. Thus, at another level poverty should also be considered in light of the environmental circumstances which impede the development of certain capabilities, such as knowledge, information, or inequality in access to resources.

Technology on the other hand refers to the aggregate of mental and physical capabilities designed to address a certain issue, e.g., a problem or production process. It involves the application of both human potentials (skills, knowledge, information) and physical or material aspects (equipment, tools and artifacts). With respect to artisanal mining, this description can be used to explain the objectives of efficiency, whereby technology is referred to as 'an aspect of the relationship between man, the natural environment and the satisfaction of material needs and wants' (Givan and Sangster (1983) in Nguluma 1990). It assumes a process linking the natural resources and people's capabilities to tap their material necessities from it. Technology can thus be adopted to inject or enhance human productive capacities. This situation can be conceptualized through the following aspects:

Employment: technological development allows more efficient use of human labour and absorbs the unemployed and taps other sources of labour particularly the disadvantaged through easing of complicated production processes especially with respect to women in mineral extraction.

Economic: technology has ability to improve or raise productivity and incomes. In artisanal mining this may be realized through an increase in net benefits accrued after enhancing the production processes and savings may be possible to allow re-investment in mining or other economic activities.

Time: It is assumed that if technology facilitates the easing of the production process, more time would be saved and directed towards other activities. Thus mining can also be developed into a self sustaining occupation if some extra time is gained particularly because most miners are also engaged in other economic activities, such as agriculture, business or trade.

Health and Safety: Technology minimizes accidents and makes the production process safer and healthier. Also, it is expected that the use of equipment like air compressors, water drainage facilities and others reduces physical discomfort and illness and thus leads to better health, lower medical costs and increased production.

> ***Environment:*** Mining technology enhances the ability to re-claim land after use for other activities and enables the prevention of pollution (e.g., of water bodies) by mercury used in gold production..

Nguluma (1990) terms this description mechanistic definition which does not take into account the social relationships involved in such technological applications. This is because, technology does not only entail 'mechanistic aspects', it also embodies social aspects related to the organization of production and the nature of other social relations related to the processes of production, distribution and consumption (Nguluma 1990). Generally, investment in technology by most production enterprise is often based more on economic principles than social objectives, whereby profit maximization with minimum costs is regarded as primary rather than adressing issues like promoting employment and higher income levels. As such, the profits accrued may not necessarily benefit all actors in the production process, and insensitivity to the inequalities make poverty alleviation attempts irrelevant. Technology may be sensitive to production but fall short of addressing issues of consumption patterns and the nature of distribution. The organizational aspect of technology is thus instrumental in promoting a poverty sensitive technology.

Technology does not operate in a vacuum. According to Chungu and Mandara (1994) the terminology 'technology climate', is normally what determines the nature of the technology to be applied, its effectiveness and its social and economic implications within the sphere it operates. This implies that while the processes of poverty involve other broader processes, such as lack of an appropriate technological infrastructure, inequitable macro-economic policies, depletion of environmental resources, etc., which deny people access to basic amenities in life, they are often mediated by institutional structures of law, policy, entitlement and practices which shape an individual's access to and control over resources. Poverty within artisanal mining can thus also be seen as an outcome of the limitations in the institutional and organizational framework guiding the sector. These factors, invariably, determine or influence decisions for investing in the mining technology. The social organization of production and the nature of the inter-relationships between the different actors in mineral production, nature of mining rights as provided by law are among the various factors which have determined accessibility to, availability of and control or ownership of appropriate technology for artisanal mining.

4.0 RESEARCH FINDINGS

4.1 General Issues

4.1.1 The Population

Various factors influence the accuracy of the size of the populations involved in artisanal or small scale mining activities in Tanzania. These include the miners periodic shifting nature to other areas and the inability to distinguish between those involved in direct production and those offering support services. Thus, only estimates were used in this study.

At the time of this study (Feb. 1996), the total population in Mgusu was estimated at 8 - 10,000 people with about 1500 - 2000 people engaged in direct production. The estimates of people involved in direct mineral production is based on the number of operating pits which were nearly 200 at the time of the visit with 120 having been abandoned as a result of miners shifting to Bulyanhulu and Tunduru in search for more greener pastures. Estimates at Rwamagaza puts the population between 3 - 5,000 with most being permanent members of nearby villages. The figures were estimated from direct interviews with some claim holders and pit owners on their manpower levels. The number involved in mineral extraction was much smaller although their productivity was very high as a result of mining from shallow depths. The pits usually employ an average of 6 people working one shift only and the active pits in the areas are estimated at around 50 - 80 thus, mineral extraction workers can be estimated to be between 300 - 480. There are large groups of workers in processing areas due to large turnover of pit workers. This group was estimated to be about 300 people including those providing specialized services like blasting, pit support, etc. Given the fact that the time of the year during the field visit was an agricultural season and some miners switch between agriculture and mining, the population of those directly involved in mining at Rwamagaza is put at 1000.

According to the Mabuki village government which seemed active and aware of mining activities in the area, there were 27 registered mining groups of about 6-10 people each. This would put the number of those directly involved in mining in the area at around 142 - 270. Mabuki mining village is different from other mining settlements in that there is some kind of a formal small town located along Mwanza - Shinyanga road where all the trading is carried out. As such, the trading activities do not only target the miners, but also travellers. There was no indication of working in groups as registered by the village government and although the groups were formed to facilitate the application for mineral rights and solicitation for aid by having some form of cooperatives. It was assumed that all those registered in groups work in the existing pits. The number of pits were also probably twice or three times the number of miners although most had been abandoned due to involvement in agricultural cultivation.

Data from Merelani indicates that the number of registered claims in Block B and D are 304 and 290 respectively. Every claim in Block D has one pit, while in Block B, approximately 60 claims have 5 to 8 pits and the rest have about 1 to 2 pits. Basing on the

estimates of 15 to 20 people per pit, this estimation gives us an average figure of 13,410 engaged in direct production plus about 3300 (which is about 1/4 of total number in direct production) offering support services giving an estimated population in Merelani as about 16,710 people. The Zonal Mines Officer indicated that occasionally, when a pit strikes the Tanzanite pocket, many workers flock in to try their luck and more than 50 people can be found within such pits.

In Matombo (Ng'ongolo), it was estimated that on average, the alluvial mining areas employ between 30 - 40 people per claim and about 6 people per pit in hard rock mining. All areas have one morning shift. At the time of the visit, there were 8 claim holders in alluvial mining areas and four hard rock mining claim holders with an average of 3 pits per claim giving an estimated 240 - 320 alluvial gemstone miners and 72 hard rock gemstone miners, which is 312 - 392 people directly involved in mining. There was not much trading in the area and most people seemed to lead a normal village life unperturbed by nearby mining activities.

4.1.2 Work Organization and Division of Labour

There are variations in the division of labour within the artisanal mining sub-sector most of which are neither known nor recognized by the Government. These have evolved from several processes. For example, despite having no starting capital most claim holders and other operators have resorted to these activities whose rewards are based on productivity. The Zonal and District mining offices also acknowledged the existence of these divisions of labour with no official recognition, and as such, have no mandate to intervene in labour disputes and payment arrangements. The office only follow up payment of royalty and the normal mine inspection. The division of labour in direct mining and indirect activities can be summarized as follows:-

(a) Claim Holders

This is a group of men and women who have gone miough the bureaucratic procedures of obtaining a mineral right. Most claim holders lease their claims to pit owners who in turn assemble a team of workers to carry out the mining. Claim holders are usually absent from mining sites but employ security guards (in most cases, relatives) to make sure pit owners do not understate their production figures. Earnings are usually through a sharing scheme whereby the claim holder takes 30-40% of the earnings leaving 60-70% to the pit owner and his workers.

(b) **Pit Owners**

Pit owners are usually the people who rent part of the concession from claim holders in order to carry out mining. They have their own team of workers whom they provide working tools, food, and other social facilities like health care. Some pit owners are also mineral brokers, a role which tend to boost their earnings. Most pit owners are men. The women attain pit ownership status by investing their earnings from food and drinks vending. It is thus easier for women pit owners to provide supporting services than their male folk despite the discrimination especially in gold mining areas.

(c) Mine Workers

Mine workers do the manual work of rock excavation. In most cases a team of mine workers is put together by the pit owner who is in charge of all mining operations in a pit. In underground operations, in both gold and gemstone mining areas visited, all mine workers were men. In alluvial mining areas both men and women were involved but women worked in large groups as a way of countering male domination. These groups usually involve family members, including children and some old folk who do the light work of washing. Children also do the courier jobs as directed by their elders.

(d) Reprocessing of Tailings

This group is dominated by women more than other mining operations. Tailings worked by these groups are found in old mines, (e.g. at the old Geita Gold Mine), in existing formal mines (defined as illegal activity) and from both abandoned and existing artisanal mining areas. The attraction of this activity is that less investment (usually a shovel and a pan or shovel and timbers for a sluice box, screens) and it is less labour intensive. The inferior technology used in retreating these tailings results in very little earnings. Panning and sluicing are suitable methods for treating unprocessed ores containing coarse mineral particles. Tailings usually contain finer particles that are difficult to catch through gravity concentration alone. For example, treatment of gold tailings requires the use of chemicals like cyanide. Apart from the meagre earnings, this group also faces the danger of catching dust related diseases. This is because the material being treated has already been ground to very fine particles which produce respirable dust. This group is also dominated by women and children.

(e) Specialised working groups

These are groups of workers carrying out specialised works, usually on contracts in areas like mineral processing, mine supports, blasting, excavation of pits, etc. For example, in gold mining areas women are hired to fine-grind the ore after it has been manually crushed. In addition, after amalgamation, the tailings are usually dried, roasted and then reground in order to free the finer mineral particles. Grinding stones are the commonest tools used for crushing. Panning and washing on sacking strakes and sluice boxes are some of the processing jobs that are carried out on contract basis. In areas where mine inspection is regularly conducted, pit owners give contracts to those with blasting certificates so as to uphold the law.

(f) Service Provision

The services provided by this group include food stuff and drinks vending, trading, and, supplying water and food to pit workers on special contracts who in turn get a share of the mineral proceeds once realised. Some maintain accommodation and bar facilities, a lucrative business in mineral production areas judging from the frequency of trade transactions taking place and the spendthrift character common in most of these areas. Others maintain stalls (magenge) selling clothing, household utensils, and agricultural produce. This group is usually dominated by women and experience has taught them to be

tough since miners often do not pay for their services when they get their money, taking advantage of women's assumed weakness.

4.1.3 Groups Interrelationships and Modes of Operation

Most miners enter the trade with very little or virtually no working capital and resources. Many are sponsored either by claim holders, mineral traders or businessmen/women under agreed terms. The relationships between mineral dealers and brokers and the production groups named above, range from minerals trading to provision of financial or material support (sponsorship) for production activities. Mineral dealers and brokers usually provide such support on agreement that they have guarantee to purchase all minerals produced so that their investments are recovered. It was alleged by most claimholders in Arusha and Morogoro that Brokers collaborate with their mine workers who steal the best stones and sell them to brokers at low prices and thus affecting the market. Some claimholders and pit owners also operate as mineral dealers and brokers and thus complicating the relationships further. In such a case, the claim holder obtains share after production. If material support is provided the miners are require to sell their share to the claim holder. Most business men and women living in nearby towns also provide credit facilities, e.g., those in Maganzu who support the diamond mining activities at Mabuki. The terms usually attached to these informal credit facilities and the strict monitoring imposed make this relationship an uncomfortable marriage of convenience.

The support of production activities is not always based on provision of cash. For example, most women provide food, drinks and other social services on the understanding that miners pay when earnings are realized. The main characteristic of these groups is the sharing of the production proceeds. In most cases the ore is distributed at a pre-determined rate e.g., 60% or 70% for the pit owner and his workers, and 40% or 30% for the claim holder. Sometimes the pit owners and mine workers are paid by working in a shift of their own for 1 - 3 days. This arrangement has made many Claim Title (CT) owners capitalize on the workers need for employment at the expense of investing on their pits/mine areas thus leaving the workers to facilitate the accumulation of money.

The location of most artisanal mining activities makes their interaction with large scale operators inevitable. Most of these operators are still at exploration stage and occupy large areas of land some with pockets of artisanal mining claims within the licensed area. This has usually resulted in pressures from large operators to secure exploration rights in neighbouring artisanal mining claims through negotiated agreements. These agreements which are usually conducted without Government intervention, are of different modes. Some of these modes include an initial payment which provides access for preliminary investigations in a particular claim. Once the claim has been categorized as potential, further negotiations are conducted either for outright transfer of mineral rights or a Joint venture agreement. The negotiations between Rwamagaza artisanal miners and the East African Mines Ltd., is one such example. In this case, miners refuse the offer for the initial payment on the grounds that they were offered a raw deal. It was also noted that in most cases the relationships between miners (usually Claimholders) and large operators, is of a

suspicious nature. This is aggravated by the fact that sometimes the Government allocates the same area to the two groups (e.g., Rwamagaza and the former Dar Tardine Tanzania Areas). In other cases, unlicensed artisanal miners invade areas allocated to large scale operators and it takes too long to remove them, e.g., in Bulyanhulu. Such incidences have strained relationships between the two groups.

At the time of this study, Mgusu was operating as a company whose relationship with the miners was limited to sub-contracting them to the pits. Every working day, the pit 'headman' or shift boss, registers the number of workers available. The company was also responsible for medical assistance in case of accidents, and an occasional inspection of the pits. The organization has no representation of the miners other than the 'land lord - serf relationship. All pits are numbered and each has a shift boss. Work is usually carried out in two shifts, a day and a night shift. The veins mined at Mgusu have widths of 1.5-2.Om. Usually 4 people work underground at any one time during the 12 hours shifts, sometimes exchanging with those on surface doing hoisting or driving the manual fan.

Mining at Rwamagaza reflects what has become synonymous to artisanal mining, i.e., disorganized operations. Every claim holder leases part of his claim to pit owners who inturn assemble miners and work independently. Consequently, there hasn't been any monitoring and records are not easily available. On average, a pit has 6 people at any one time with 2 working underground and 4 on surface interchanging from time to time. Working on shifts is dependent on the pit owner and his crew. Where drilling is practiced one person manually drills a 1.0m hole per day. On average 10 holes blasted would take 2 drillers 5 days.. A face is estimated to have a cross-section area of 1.2mxl.0m. Volume blasted = 1.2mxl.0mxl.0m = 1.2cu.m which equals 0.24cu.in/day or (0.24cu.m/day x 2.65t/cu.m) = 0.64t/day.

In Mabuki the village government keeps a register of those involved in mining. The miners are organized in groups of 6-10 people and each group has a name. There are 275 registered mining groups. The majority of these groups have applied for prospecting rights (PRs) although none has a pegged claim because of land conflicts. Despite this organization, what transpires at site is quite different. Miners work individually or with a friend with no regard for their groups. Most of the pits visited had one or two people working. However, according to the miners, 4-6 people work in a pit during the dry season. The rest work as labourers who resort to farming during the rainy season. Piles of 7-10 tonnes of gravel were found reflecting that production took place in the dry season. If a 5-day working week is taken into account, then a 3 month-dry season has 60 working days which reflects productivity of 0.12-0.17 tonnes/day. For a crew of 4 people, this amounts to 0.03-0.04 tonnes per man-day.

Work organization at Merelani is at pit level. Every pit owner runs his operations according to his own style. Most pit owners in Merelani are claim owners and thus charged with the provision of basic amenities, water, working tools, etc. Labour divisions within a pit depend on experience of the miners and preference of the pit owner. Workers are usually

divided into the steering-men, also known as "stelingi" who are experienced in blasting, mucking and hauling, and the ordinary labourers. Although most pit owners stay at the pit mouth they maintain a close ally, usually a relative or close friend underground to monitor production. The most distinguishing feature at Merelani is that despite working together underground, each blasted round and hence material belongs to an individual group member(s). Pits employ up to 30 people working in different shifts and the number changes depending on productivity.

Matombo on the other hand has various work patterns. The claim holder in hard rock mining usually employs 6-10 people working on full-time basis. They are paid a regular wage of 400-5007= per day plus food supplies. A shed for accommodation or restage in between shifts is also provided by the claim holder. Sharing of material as a mode of payment is not very common but is sometimes practiced depending on the financial situation of the proprietor. Drilling is done manually, using a drill steel, hammers, and water. 2 holes (1.2 - 1.8m) are drilled per day by a team of 2 people. One of the claim holders visited in alluvial mining, had about 40 miners working for him. Two of his family members (1 son + 1 brother) were the supervisors. Workers are paid through sharing of ore, 50: 50%. Sometimes a miner may be given a piece-work for an agreed rate of payment.

4.1.4 Productivity and Incomes (a)

Productivity

In Mgusu, 4 people usually produce one bucket of ore per shift, estimated to about 0.034 tons per shift (bucket volume 20 litres, density of broken materials in loose piles - estimated for greenstone = 1.714 tonnes/cu.m) or 0.068 tons per day. Gold production estimates put it at 4-6 gm per day. With a recovery rate of 70%, the average grade of ore mined varies from 84 gm/t to 126 gm/t. This is comparable to actual laboratory test results of samples carried out by State Mining Corporation (STAMICO) and BOLIDEN CONTECH in March 1994 which reflected a grade of 91 gm/t for intermediate rich ore and 28 gm/t for coarse tailings at riverside.

Estimates for gemstone mining were difficult to establish. For example, Tanzanite is usually contained in pockets that are rarely encountered. Therefore, tonnes of ground have to be removed from underground before reaching a productive pocket. However, when a rich pocket is hit a lot of Tanzanites may be produced. Productivity rates on daily, weekly or monthly basis, are thus difficult to make, a typical case to all artisanal gemstone mining. The production figures for Matombo are estimated since during the visit, there was an acute shortage of water which hindered any recovery. When there is enough water for washing the gravel an estimated average of 3.5 tonnes can be washed per day using the screening method available.

Table 4.1: Mining Productivity

Mine Site	Ore body width (m)	Mining depth (m)	No. of Miners/pit	Ore Kgs/day	Productiviry Kgs/man-day	Average grade g/tonne
Mgusu	1.5-2.0	20-150	8	68	8	84-126
R'magaza	-	5-15	6	640	106.7	120
Merelani	-	50-150	30	*7000 56000	*233-1867	-
Mabuki	-	2-5	4-6	120-170	30	-
Matombo		4(A) 10(H)	40(A) 6-10(H)	*2000 (A) 600(H)	50(H) 100-600(A)	

*These are tonnages of blasted waste rock removed in accessing gem bearing rocks.

A= Alluvial, H= Hard rock

Table 4.2: Drilling and Blasting data*

Location	Drilling Mechanism -	Drillers/ Shift	Holes/ Shin	Shin s/ day	Hole length (m)	Blasted holes/ round	Explosives Kg/roun	Rounds Blasted /day	Re-entry Time (Hours)***
Matombo	Manual	2	1	1	1.2-1.8	10	3-4	**	12
Rwamagaza	Manual	2	2	1	0.6-1.2	10	3-4	**	6
Merelani	Manual Machine	3-4 4	10 30	1 3	1.0 1.0	10 10	3-4 3-4	1 8	24 1

* No drilling and blasting at Mugusu and Mabuki.

** On Average a round of 10 holes is blasted per week.

++ Only about 30% of the pits use explosives.

*** Re-entry time - Time to clear out fumes before work resumes.

Table 4.3: Processing Productivity

Mine site	No. of people processing	Kg.(Ore) processed 7 day	Processed Kg/manday	Average grade of oreg/t	Expected production (gms)	Actual production (gms)	Recovery (%)
Mgusu (gold)	6	68	11.3	105	7.14	4-6	70%
R'magaza (gold)	15	130	8.6	131	17.3	12	71%
Merelani (T'nite)	10 per shift	manual sorting	N/A	N/A	N/A	erratic	N/A
Mabuki diamonds	4	4000-5000	1,000	~	N/A	erratic	N/A

* These production figures are not based on continuous operation. Mining may be carried out separately while stockpiling ore for processing at later stages.

(b) Incomes:

At Mgusu, production levels had dropped significantly to 4-6 grams a day, due to the transient nature of their activities, e.g., they periodically shift to Bulyanhulu, and of late to Tunduru. At the current price offered by NBC (February 1996) of Tshs 4,2507= per gramme of processed gold and TShs. 45007= per gramme of native gold, the average daily incomes are TShs. 17,0007= - 25,5007= and 18,0007= - 27,0007= per day respectively, (Table 4.4). The parallel market prices on the other hand vary from TShs. 6,0007= - 7,0007= or 24,0007= - 42,0007= per day. This explains the dwindling of sales through the legal channels. Production is usually erratic and thus difficult to assess. Initially, the marketing of all gold produced was controlled by the title holder. From June 1991, after intervention by government, the miners claim to sell all their produce through the banks. Occasionally, private dealers purchase the gold. According to Geita District Mines Officer, a licensed dealer is required to get a clearance letter from his office before visiting the mining sites to buy gold 70% of the proceeds is distributed among the miners while the title holder claims 30%.

Table 4.4: Comparative Gold Prices (USS/Troy Ounce) (February, 1996)**

	Native Gold	Processed Gold
World Market	-	380
Bank Prices *	232.5	219.6
Parallel Market	361.7	310

*Banks = National Bank of Commerce and Bank of Tanzania.

** Gold prices vary on daily bases on all markets hence these are average prices during the project period.

In Merelani, productivity rates are kept secret making it difficult to establish actual production figures from these operations. However, judging from the material accumulation and levels of expenditure of pit owners (some claim to be spending up to TShs. 2 million a month to maintain the workforce and run the equipment), their earnings are quite substantial.

The average income per month per pit in Matombo was estimated to be TShs. 200,0007= which, using an average of 6 people per pit gives TShs. 30 - 40,000/=. Occasionally, however, the miners may scoop stones worth TShs. 1-3 million, or not get anything for a very long time. It is thus difficult to establish a fixed amount of income for such an activity. Also, there is no established pattern of distribution of proceeds. The most common patterns include; distributing the income or the stones/sand in 3 parts: 1/3 given to the workers, 1/3 for servicing the mine or pit (in terms of purchasing explosives, working tools, food, etc.), and the last 1/3 goes to the claim holder, sharing equally between the workers and the owner; or the claim holders paying regular salaries to their workers.

4.2 Technological considerations

4.2.1 Gold Mining

Two gold mining areas, Mgusu and Rwamagaza, both located in Geita were visited. Whilst there are a lot of similarities in techniques for mineral extraction and beneficiaries, there are also some unique features for each site.

(a) Mgusu Mining Area

Mineral Extraction: Pits measuring approximately 2mxl.5m are excavated and are arranged along rows in a staggered pattern. Distance from one pit to another is between 3-5m. The size and spacing are not based on any technical judgment but on the miners' intuition. Pits are dug straight down until secondary enrichment is encountered. Miners seem to have gained experience in the local geology such that pits tend to change direction as they detect loss of mineralization. Once mineralisation has been encountered it is pursued along the strike through crosscuts and roadways. The width of the roadway is in most cases dependent on the width of the orebody. Consequently, all development is

restricted to the mineralized zone. The mineral bearing rock is extracted manually. By using hammers, chisels and single-sided picks (also known as sokomoko), the ore is slowly chipped off before being hoisted to the surface. Productivity tends to reduce substantially as mining goes deeper into primary mineral enrichment which is in harder rocks. No explosives or application of rock drilling machines were observed at Mgusu. Some pits at Mgusu have reached a depth of 150m.

Mining Equipment: Equipment used for mineral extraction is mostly fabricated at the mining site and are very rudimentary. The following equipment are generally used: (i) shovels; (ii) picks; (iii) forged old drill steels with one end sharpened; (iv) ropes; (v) sacks; (vi) hammers; (v) short steel tools with one end bevelled (also known as "Ponchi") or chisel; (vi) one sided picks (or sokomoko); and (vii) buckets.

Mine Ventilation: Ventilation problems are common in Mgusu as pits get deeper. Without enough air circulating there is increased concentration of gases, dust and heat resulting in some pits being abandoned. The roadways of some pits have accidentally gone through other pits thus allowing natural circulation of air. As a result of these problems the miners designed and fabricated manually driven fans for use in two deep pits. The fan has six to eight blades of thin pieces of metal sheet welded on a 16"-19" long shaft. The driving mechanism utilizes a bicycle wheel and a rubber drive belt which connects the wheel to the shaft of the fan. A 25mm diameter PVC pipe is connected from the fan outlet down to the working face. It was difficult to establish the amount of air reaching the face, but there were satisfactory working conditions. However, the majority of the pits still operate under very dangerous conditions.

Mine Support: Timber cribs are used to support weak areas (the pits and working areas) given the weak weathered ground especially on the top parts of the pits. The construction of the cribs which is done on surface before individual planks are lowered down, is impressive and up to standard. However, the choice of timber is dictated by availability rather than quality. In that regard, all pits are supported by locally available softwood "Miombo".

Tramming and Hoisting: Tramming is the movement of ore from the face or loading point to another area within the mine, hoisting is the final movement of ore to surface. At Mgusu, broken ore at the face is either moved by using shovels or loaded into sacks and moved manually by mine workers. The decision to change from moving by shovels to loading in sacks depends on the distance to the shaft. If the material is moved by shoveling to the shaft, it is then loaded into sacks and tied to a suspended rope. There are two ways of pulling the load to surface. The first is where a group of miners manually pull the rope and hence the load to surface. The second approach utilizes a pole running across the pit mouth and supported on wooden plunks. The load-holding rope is attached to the pole which is then wound by using two handles on each end to raise the load to surface. This is the most popular method of hoisting. More innovative miners use pulleys over which the rope is run to ease the pulling. Pulleys seen at Mgusu are metal ones usually picked from junk yards. The tools are lowered inside the mine after a signal is given to ensure that there is no one at

the bottom of the shaft. At the end of the shift, they are put in a bucket or sack and pulled to surface. Pits are usually excavated with notches on either side to facilitate movement.

Gold Ore Beneficiation: The primary ore extracted from underground has to be processed before recovery of the metallic gold. Processing of the ore goes through different stages as detailed below:

Ore Preparation Processes: The raw ore is crushed manually using hammers as an initial size reduction stage. The product size of about 1 cm is crushed further in a hardwood mortar and a motor vehicle half-axle as a pestle. On average 10 kg of ore can be crushed in an hour by one person. Depending on the type of ore, sometimes fine grinding is necessary. Fine grinding up to 100 micro-meters is carried out by using a grinding stone, a job usually carried out by women and children.

Gold Production/Recovery Process: In cases of high grade ores (normally determined by miners on the basis of colour and simple pan tests), the slurry made from crushed ore is panned directly to recover the metallic gold. Low grade ores are processed by running the slurry over the inclined sacking strakes (clothed tables without riffles). Gold concentrate collects over the cloth or sack and is recovered by washing the cloth in a bucket of water. This stage is usually carried out on river banks due to high water requirements. The concentrate is then mixed with mercury to form the gold-mercury amalgam. Recovery of the metallic gold bullion is then carried out by heating the amalgam on a pan over an open fire in order to evaporate mercury.

Beneficiation Equipment: The beneficiation equipment used at Mgusu include hand hammers (4 kg), hardwood, mortar and half axle pestle; steel pans, sacked strakes and buckets. Amalgamation Retorts were also available but no usage could be established.

(b) **Rwamagaza Mining Area**

Mineral Extraction: Most of the extraction methods at Rwamagaza are similar to those at Mgusu except that pits at Rwamagaza are shallow with the deepest at 15 metres. Some pits have started employing explosives. Blasting operations are usually contracted to someone with a blasting certificate. The contractor usually provides the explosives, detonators, stamping material, etc. and 2-4 feet (0.6-1.2m) length holes are usually drilled. Most pits are left without any supports because of their shallowness, high costs of timber in the area (1 cu.m costs 50007=) and lack of appreciation of support significance.

Water Problems are characteristic of Rwamagaza despite the shallowness of the pits. Most pits encounter water at a depth of 12-15m. There were no pumps observed on site. Therefore, water is removed from the pits by using a bucket and a rope. A bucket is manually filled with water at the bottom of the pit and then hoisted to surface for disposal. Given the topography and the fact that some pits are located in abandoned quarries, the disposed-off water may find its way underground again.

Gold Ore Preparation processes at Rwamagaza are similar to those at Mgusu. At the time of visit to the mine there were about 30 people at Rwamagaza engaged in size reduction. The production rate at Rwamagaza is estimated at around 15 kg per hour.

Gold Production/Recovery Processes: Water has to be carried from some distance to the separation area. Gold concentration is through panning and a few sacked strakes followed by mercury amalgamation. The gold-mercury amalgam is then evaporated on a pan on an open fire in order to recover the gold bullion. Through interviews with the miners, it was clear that a higher grade ore was available at Rwamagaza than at Mgusu. This was judged by the increased chances of recovering gold directly from panning. It was estimated that on average 12 grams of gold are recovered from 4 buckets of crushed processed ore (about 130 Kg of crushed ore). Assuming 70% recovery, the average ore grade is 133 gm/t. Beneficiation equipment is similar to that used in Mgusu.

4.2.2Diamond Mining

(a) Mabuki Mining Area

Mineral Extraction at Mabuki is also done by pitting with some having depths of less than 5 metres. Mining usually involves removing the 0.5-2m overburden before reaching the gravel containing diamond. The gravel layer is excavated and piled on one side of the pit awaiting washing. Diamond mining pits differ from those in gold mining in that they are excavated in a trench like manner. Most of these trench-like pits measure 1-1.5m width by about 3m in length.

Due to shortages of water for washing gravel during the dry season, only extraction is done in this period. During the rainy season all pits are filled with water used for washing the gravel stockpiled during the dry season. Consequently, gravel extraction during the rainy season is very limited. Mine workings at Mabuki can also be classified as open-cast. No hoisting or tramming is required as gravel is thrown to surface with a shovel. Most pits do not require any support due to their shallow depths.

Equipment used for both overburden removal and gravel extraction are very basic. These include, a hoe, a shovel, a pick and a bucket. A bucket is used for dewatering the mines during the rainy season. Water is sometimes encountered at a depth of about 2m and must be removed. No pumps or any mechanical equipment were observed in the artisanal diamond mining area.

Water Problems: Most pits have water problems. During the dry season the water table is much lower thus enabling extraction without encountering water problems. Miners dig shallow wells in order to preserve water for use in a dry season.

Diamond Beneficiation

Processing: At Mabuki, diamond is recovered from sediments containing gravel and clay. The process applied utilizes a simple sieving system. A sieve of about 850 microns (0.85mm) is used to wash out the clay leaving the coarse stones which are sorted by hand.

After the sorting, the gravel is rewashed to clean off the remaining clay after which it is panned for diamond concentration. Having a higher specific gravity (3.52 g/cu.cm) than the surrounding gravel, diamond collects at the bottom of the pan from where it is removed by hand sorting.

Diamond Recovery: The specific throughput at Mabuki is very low due to the type and size of equipment used. Very small amounts of gravel are handled per pit per day (4-5 tonnes). In order to recover good diamonds and considering the low in-situ grade, large amounts of gravel need to be treated. Interviews with miners indicated that it is common to work for up to three months before a piece of diamond is recovered. This implies that an average of up to 360 tonnes of gravel must be treated in order to recover a piece of diamond. Processing equipment include only hand sieves and pans.

4.2.3Gemstone Mining

Two sites were visited in the gemstone mining area. Merelani in Simanjiro District, Arusha Region known for Tanzanite and Ng'ongolo in Matombo, Morogoro Region famous for its rubies.

(a) **Merelani Mining Area**

Mineral Extraction: Mining is carried out through pitting mainly in hard rocks, and has attained an advanced stage of production through the introduction of some mechanization. At least one in every four pits has an air compressor, a drilling machine and uses explosives for breaking the hard rock. Pits without compressors either hire a compressor or use manual drilling. 2 people drill a one metre (3ft) hole in an hour and on average there are about 3-4 drillers underground at any one time. In a 6 hour drilling shift, 10 one metre holes are drilled. Those using jackhammers have claims of three times this number of holes. However, only one drilling machine operated by a driller and his helper is working at any one time. No wet drilling was observed at the site.

Pits without compressors, blast one round of 10 holes and re-entry time is about 24 hours. For those using compressors, the re-entry time is reduced to about an hour thus allowing 8-10 holes rounds to be blasted per day. Three high explosive cartridges are loaded in each hole with the bottom cartridge tied to cordtex (a cable explosive) and connected to an electric detonator and exploder. Red anthill soil is used as stemming material. Two people carry out the connection and blasting retreating to surface thereafter. Miners seem to have acquired experience in detecting the orebody such that blasting is regulated to minimize damage to gemstones.

Mining Equipment: The main mining equipment include the following: compressors, drilling machines (without water line); explosives and detonators, shovels and picks, short steels with one end sharpened for manual drilling; hammers and compressed air lines (rubber hoses (12.5mm - 19.0mm), winch with a Lister diesel engine (found in one pit) and wire ropes, sisal ropes and sacks, buckets and locally fabricated wooden and metal pulleys.

Mine Ventilation: Because of the depth of most pits, ventilation is a major problem at Merelani. Most deep pits use compressed air for underground ventilation which is expensive and but the compressed air is usually damp, thus raising the humidity. A pit can hire a compressor for drilling and ventilation or depend on natural ventilation. Since natural ventilation depends on depth, a substantial number of pits, especially in Block D, have been abandoned. Some pits have had their roadway and crosscutting other pits thus creating a channel for efficient natural ventilation. No ventilation doors are used on site.

Mine Support: Timbering is used to support the weak near surface ground although most pits are located within the outcropping hard rock and hence need no support. The pits that encountered outcropping ore started as open cast mines and later were converted to underground pits. Because of the large excavation, sandbags are used to contain loose ground at the top from entering the pit. In general, mining at Merelani enjoy good rock quality with minimum support requirements.

Tramming and Hoisting: Movement of the material from the production face to the hoisting point is usually done manually. The ore is either moved with shovels (for short distances) or loaded in sacks which are then moved manually to their destination. It was claimed that one of the deepest pits in Block D (150m) had excavated a roadway 500m long. Because of this length, most of the material was stocked underground and moved at intervals especially during peak production periods. This pit has the most sophisticated hoisting system at Merelani. It uses a diesel lister engine winch to raise the rock loaded sacks to surface. A wire rope and a pulley are used for hoisting. The pit originally used a tractor for hoisting before changing to a winch. Most pits however, use wooden pulleys attached to the centre of a pole running across the pit mouth. A sisal rope attached to a load at the bottom is run over a pulley (both wooden and metal pulleys) and then manually pulled to raise the load to surface.

Mineral Beneficiation

Processing: The recovery of Tanzanite gemstones starts from underground where controlled blasting is carried out in order to free the gems from the schist mass host rock.. Hand hammers are then used to carefully break off the remaining attached schists without affecting the gems whose hardness is only 6 (Mohr's scale). The gems are then hand sorted. The whole process is carried out underground as a security precaution to avoid exposure of one's earnings. However, there is limited working space and improper lighting underground. In some cases panning is done on the surface in order to recover smaller pieces not easily collected through hand sorting underground. The gem is already a marketable product after hand sorting. Processing Equipment include small hand hammers and steel pans.

(b) Matombo - Ng'ongolo Mining Area

Mineral Extraction: Two different types of mining systems are practiced here, namely, surface alluvial and underground hard rock mining. More people are engaged in alluvial than in hard rock mining. Hard rock mining utilizes inclined adits with the angle of

inclination (about 60) following that of the rock bedding planes for ease of rock breaking. The rock is manually drilled by using a specially forged drill steel and a hammer, and water. The adits are still shallow with average depths of about 10m. The length of holes drilled are 1.2m-1.8m (4-6 feet) and a round of 10 holes is usually blasted by a hired blasting license holder. 6-10 people work on full time basis carrying out all mineral extraction duties.

In alluvial mining, zig-zagged trenches are excavated and are slowly expanded to cover the entire mining area. Mining starts by removing the 2-4m overburden before reaching the gem containing gravel. Gravel is then shovelled to the surface for washing. Given the large size of these excavations, up to 40 people worki at the pits at a time. Some alluvial excavations start as pits with large arial extensions e.g. 5mx4m and are systematically expanded in order to extract the underlying gravels. Hard rock mining pits are still very shallow thus enjoying natural ventilation. One to two hours is usually required to clear the fumes after blasting. Mining is done in good quality rock requiring mining support.

Mining Equipment: No mechanical equipment in either extraction or processing operations were observed. The working tools in both mining systems are picks, shovels, hoes, hammers, sharpened drill steels or chisel, sisal ropes and sacks, and buckets.

Water Problems: Alluvial mining is carried out in a low land area usually flooded during the rainy seasons thus limiting mining to dry seasons only. The shortage of water makes washing of gravel difficult. Water holes are thus dug and used to provide water for washing gravel. No water problems in hard rock mining areas have been experienced so far.

Ruby Beneflciation

Primary Ruby Processing: Ruby particles are extracted from the host rock by using hand hammers (4 Kg). The ore is extracted from the rock between marbles and gneisses which constitute a main component of the gangue material. The hardness of rubies (9 on Mohr's Scale) makes its extraction from the attached gneiss and marble easy by hammering. The small rubies are separated from other particles by a combination of sieving and hand sorting.

Alluvial Ruby Processing: The process of recovering alluvial rubies is easier than that of primary ones. The alluvial rubies are found concentrated in beds of gravel and clay. The clay is washed out in the pits through screens of about 1 - 2mm sizes. The gravel is further screened outside the pit followed by several stages of sorting to remove large stones. Ruby particles easily seen because of their attractive colour are easily hand-sorted during the screening process.

Processing Equipment found at site include, hand hammers and l-2mm sieves.

4.3 Institutional and Organizational Aspects

4.3.1 Institutional Framework

The Mineral Resources Division (MRD) of the Ministry of Energy and Minerals (MEM) is reponsible for the mineral sector policy formulation, promotion, regulation and facilitation of the overall development of the mining sector. The division with its headquarters in Dodoma is under the leadership of a Commissioner stationed in Dar-es-Salaam. The Commissioner who is also the advisor to the Government on all matters related to the mineral sector, is responsible for all administrative and technical functions and ensures all revenue collections of the sector are done. These tasks are performed through 8 Zonal and 14 (16) Resident/District mining offices located in different regions.

The fast growth of the mineral sector as a result of the ongoing macro-economic reforms, (e.g., it was 24% in 1992), has rendered the present organizational structure of the MRD basically inadequate for efficient and effective management of the sector. There are basic problems such as, shortage of staff, the lack of working facilities, a small budget for monitoring and inspection of mining areas, and shortage of technical expertise. In addition, under the new macro-economic reforms, the Government is expected to relinguish its role as an investor and developer and remain as a regulator, promoter and facilitator, with the private sector playing a leading role in development of the sector. There are also new activities which have further overwhelmed the capacity of MRD. Such activities include, environmental management, mineral trading, promotion of the sector in a competitive world among others.

As regards the artisanal mining sector, there are several factors associated with problems in regulating and overseeing the sector. For example, most of the operations start informally, e.g., the Tunduru rush of 1995 and the miners lack permanency due to periodic shifts to 'greener pastures' once mineral deposits are depleted or exploited. There are also inadequacies within the overall institutional structure. In some cases, the Government has shown weaknesses in converting policy directives into operational terms even where they are favourable to the sector. In addition, the slow speed at which the Government reacts to miners' complaints, tends to exacerbate the situation. For example, the failure to react quickly to land conflicts in Mabuki, Rwamagaza, etc., and instead blaming the miners for refusing to move into government allocated areas, is bound to worsen the situation. In addition, in some areas, the speed in which artisanal operations have been initiated, has surpassed the capacity of the Government for surveying, mapping and allocating plots and permits to artisanal operators.

The relationship between the local governments and the mines offices is another matter of concern. Under the law, the Commissioner for Mineral Resources can designate the District Commissioner in an area (Designated Officer), to receive and endorse applications for mineral rights before sending them to the headquarters for processing. However, there were indications that most districts assume this as one of their functions. In addition, most Local Governments pass by-laws without any consultation with the local mines office. For example, the Geita District Planning Officer mentioned that the district has developed by-

laws designed to tax all mining activities in the area and the proposed rates were awaiting the approval of the Minister for Local Government. It was also confirmed that this was done without the knowledge of the Geita District Mines Office. Suffice it to say however, that the Regional and District authorities have some positive influence on activities of small scale mining through intervening in disputes, organizing and monitoring of cooperatives (including mining cooperatives) and general maintenance of law and order.

Ownership Rights: This aspect was observed in terms of the status of ownership of mining claims to warrant security and continuity in the production processes. Of all sites visited, Mabuki and Merelani were more affected by this issue. In Mabuki, conflicts related to ownership were expressed by the village government, the miners and the Zonal Officers in Mwanza. Although most of the registered groups had applied for prospecting rights, none had had their claims pegged. According to the miners, the government was forcing them into uneconomic areas in the interest of large scale operators. Consequently, miners refused to have claims pegged within the government allocated areas. They also complain of the bureaucracy involved in obtaining mineral rights, such as having to travel to Mwanza to collect the Zonal Officer just to learn that he is busy with other duties or has traveled. In addition, they complained that some of the large miners have been given areas originally worked on by artisanal miners who had not had any mineral rights. The Zonal Office, however, maintains that the Mabuki area had already been surveyed and formally mapped for mining, and the small miners were given the option to select areas outside the blocks earmarked for large scale mining, which they did not do. Furthermore, they maintain that the location of the mining blocks for artisanal miners was done by considering some technical parameters, e.g., the amount of overburden and the miners ability in stripping thick overburden.

Merelani has its own share of conflicts in ownership rights. Following the governments' drive to attract, promote and encourage private investment, Merelani was in 1989 apportioned into 4 blocks and leased to different owners which systematically cut off the free for all attitudes which existed earlier. While Block A was leased to Graphtan Ltd, a joint venture company between SAMAX Resources and Tanzania Gemstone Industries (TGI), Block B was partly leased to a locally registered foreign company namely Building Utilities Ltd, and partly to small-miners directly. Block C was leased to a local private company namely Kilimanjaro Mines Ltd. Block D which was earlier leased to Arusha Region Miners Association, AREMA, for its members was later re-allocated directly to miners following ownership conflicts. The apportioning and leasing of land to these various owners is still a controversial issue. According to the miners, there is serious conflict in claim ownership in Blocks B and D nicknamed 'OPEC' and 'Baghdad' respectively because of their high output capacity. (This is despite their vivid condemnation of the state for leasing part of Block B to a private company, Building Utilities). The miners contended that the conflicts are an outcome of the recent Ministerial (MEM) interference on the re-allocation of claims to the miners. It was alleged that from 1991, MEM has been constantly influencing AREMA's organizational capacity and its ability to handle title or pit

allocations to the extent that there has been serious favouritism practiced in the recent reallocation of claims.

The District Mining office in Geita acknowledged that there was some conflict in ownership rights between the individual Claim Title (CT) owners of Rwamagaza and the East African mines Ltd currently operating the Buckreef gold mine, a situation which has been fueled by the government, it was claimed, because of the latter being allocated an area^ already under artisanal workings. According to the Government, the Rwamagaza saga dates back to the early eighties when Dar Tardine Tanzania Ltd, DTT, was licensed to operate in the area. DTT negotiated with the miners to operate as the company's sub-contractors. After DTT contract was terminated, the Government decided to return the areas to their original licensed owners, the artisanal miners. At the same time, East African Mines Ltd had applied for a prospecting license in the area. The license was issued but with instructions to respect ownership rights of the licensed artisanal miners, hence, the allocated area had pockets in it. According to East African Mines, although the government returned the areas to their original owners, it did not ensure that artisanal miners went back to those areas. As a result, miners were grabbing land which by then had already been licensed to East African Mines. On the other hand, miners expressed their fears that the Government has permitted a step by step compensation so that as their CTs legally phase out gradually, they will be removed from the area. These fears could not be substantiated and it was established that the modalities for compensation were left for the two parties to draw. The compesation/working partnership offered by the East African mines was rejected by artisanal miners on claims that they were being offered a raw deal. An element of mistrust and suspicion from both sides was detected and could be the major hindrance.

4.3.2 Marketing

In 1988, the government liberalized trading in gold and gemstones and issued Dealer's and Master Dealer's Licenses to private businessmen. The Bank of Tanzania, initially also through other local commercial banks, e.g., the National Bank of Commerce (NBC) and the Credit and Rural Development Bank (CRDB), started to purchase gold at competitive market prices. The liberalization of mineral marketing has helped provide artisanal miners and related groups access to reliable markets. In addition, regular gemstone auctions have also helped, to some extent, to combat black market dealings.

However, it was alleged by the miners that although the BoT provided the most well organized marketing system, its pricing system was unfavourable. From June 1991, after intervention by government, the miners claim to sell all their produce to the Bank of Tanzania (BoT) through NBC. Occasionally, private dealers purchase the gold. According to the Geita District Mines Officer, a licensed dealer is required to get a clearance letter from his office before visiting the mining sites to buy gold. The Mgusu office confirmed this by saying they always demand such a letter before doing business with private dealers. Miners in Mgusu and Rwamagaza were quite skeptical of the prices offered by the BoT, claiming that they fetch almost twice as much from the black market dealers. They cited that 12 gm (1 tola) fetch TShs. 75-76,0007= and TShs. 80-88,0007= for alluvial and reef

gold respectively at the black market, while the BoT offers TShs. 52,0007= and TShs. 54,000/= respectively for the same. This fact, as the miners claimed, encouraged illegal dealings. Complaints on the centralization of government buying centres, claiming that they were too far from the producers was typical of all the areas visited.

Other related problems were also evident even where markets were available. For example, the official marketing for Tanzanite is done through auctions, but because of the trickery of under valuing stones done by the Master Dealers and brokers who control the market and the prices, the miners were often compelled to sell the gem through other channels.

Lack of an appropriate marketing system is also Matombo's biggest problem. The miners accuse the brokers and Master dealers for monopolizing ruby marketing and in the process capitalizing on the miners ignorance to put prices down. It was claimed that the Master dealers used manoeuvres to export uncut rubies and thus profiting from the added value abroad while the miners received very low prices for their rubies. During the period of this study, MOREMA convened a meeting on May 5, 1996, to write a statement to the Minister against the Master dealer's mal-practices. MOREMA leadership was particularly against Brokers, whom they claimed took advantage of the low investment capacity of the claim holders and hence the inability to pay their workers well. They claim Brokers 'buy' workers so as to sell them the minerals from their share of ore. A similar complaint was echoed by AREMA in Arusha, where it is claimed that brokers collaborate with untrustworthy miners who in turn steal from the claim holders and sell the gems at give away prices. It was further alleged that brokers quickly cross the border (most have motorcycles) to sell the Tanzanite on the parallel market.

4.3.3 Finance and Credit

Financial aspects explored in relation to artisanal/small scale miners have been both in terms of reviewing the existence of financial institutions and organizations willing or able to provide such support, and in relation to what the Mining policy has to offer in terms of protection or promoting the provision of such support.

Most of the Financial Institutions consulted indicated willingness to provide financial support to artisanal miners provided that special conditions are fulfilled. However, only a few of them indicated open commitment to support such a sector. For example, the National Bank of Commerce (NBC) pointed out that in order to qualify for a loan, miners should have permanent residence, adopt the tradition of opening bank accounts, keep records of their earnings and control their incomes. Another major NBC requirement was the presentation of a valuation report indicating an approximate volume of ore reserves.

The National Income Generation Programme (NIGP) has so far identified projects related to agriculture, infrastructure, small businesses (or micro enterprises and informal activities) as possible areas for support. Chances are open for small scale/artisanal miners to benefit from the financial support of the programme. To qualify for NIGP financing, a group of

miners should submit a project proposal for approval by NIGP's Project Approval committee.

The Small Industries Development Organization (SIDO) also provides financial support in terms of loans for equipment. Depending on the amount of the requested loan, the applicant may be required to have a guarantor with assets that can be used as a collateral. Some of the specific features of such loans include:

- A technical project appraisal write-up;
- A registered business name;
- The loan carries an interest rate of 30%;
- Payback period is from 2 - 4 years (depending on the size of the loan);
- Down payment of 20% is required;
- There is a grace period of 3 - 6 months (depending on the size of the loan).

According to SIDO, some gemstone dealers in Arusha have already benefited from this facility in terms of gemstone cutting equipment. Other beneficiaries are salt miners in Tanga, Lindi and Mtwara regions.

Other institutions proved too complicated to be appropriate to artisanal miners financial requirements or capacities. For example, The Tanzania Development Financing Company (TDFL) finances projects in the region of US$ 30,000 to a maximum of US $ 1,000,000. The figures being 10% and 60% of total project investment respectively. To qualify for the minimum offer, the miner must have own investment of US$ 270,000 i.e. Tshs. 162/= million.

4.3.4 Miners Associations

The formation of cooperatives is emphasized by virtue of its strengths in promoting the welfare of artisanal or small scale miners. It is contended that the creation of cooperatives has been one of the more successful ways of stimulating artisanal mining in developing countries. Some of the significant advantages associated with the establishment of mining cooperatives are;

(i) They have the capacity to achieve significant financial power and longer term viability, and have easier access to mining and processing equipment; hence, (ii) Output is increased, therefore, increasing the income of the members of the cooperative, and (iii) May have stronger and more effective bargaining power through mobilization and advocacy. To emulate such successes the formation of Miners associations and groups has been greatly encouraged. To date, Regional Miners Associations (REMAs) have been formed in every region with active mining. Their objectives have been outlined as: to unite all miners within the region; to advise on all mining related matters; to represent and ensure miners' interests; to look for markets; to facilitate the provision of skills and training for the miners and to search for appropriate technologies (TANDISCOVERY 1995). It was however observed that the REMAs have hardly served their objectives apart from being occasional forums for mobilization and representation in mining disputes. Weaknesses in leadership and low financial capacity have been attributed as the major factors affecting the REMAs as representative bodies. Brief remarks on the relevant associations are as follows:

- **The Mwanza Regional Miners Association, MWAREMA** has its headquarters in Nyarugusu which was too far from the selected study sites. However, within the three sites visited within the region, only Rwamagaza had representation of MWAREMA. There was a sub-branch and its chairman was one of the claim owners. He gave an impression of close cooperation between MWAREMA headquaters and Rwamagaza. At Mugusu there was little knowledge of the existence of such an association and what its functions were. Equally, MWAREMA was not represented among the diamond miners of Mabuki. Whilst miners agreed to have had the knowledge of the existence of such an association, they felt it was a gold miners' association. In addition, they accused it of shying away from Mabuki because it may be partly responsible for the on going claim ownership disputes. With realization of the benefits of such an association, the village had instead established a Committee to oversee mining activities in the area and the miners had formed their own association "Umoja wa Wachimbaji Mabuki" (UWAMA). At the time of this study, there were not any strong indications on the dynamism of UWAMA.

- Small scale miners in Arusha region are organized under **AREMA.** Miners at Merelani claimed to regard AREMA positively in the past especially because it could maintain organized production, security from theft and deal with miners' conflicts. However, problems arose later and were related to lack of accountability and accusations of the officials' close linkage with the government which weakened the miners trust on the association.

- In January, 1993, **MINASCO (Merelani-Naisinyai Small Scale Miners Cooperative)** was formed, "to avoid" AREMA's bureaucracy, it was alleged. MINASCO, as the name indicates is formed by miners from the two villages bordering the Mbuguni claims, Merelani and Naisinyai. It has more than 1000 members (Feb. 1996) and was allocated 100 claims in the area. MINASCO leadership claims that their membership has extended up to Dar-es-Salaam and it is open to anybody, i.e., claim holders, ordinary labourers, pit workers, businessmen, etc. The membership fee of Tshs 10,000/= can be payable through five installments of Tshs 2,000/= each. However, some of the miners interviewed at the work site expressed dissatisfaction with the way MINASCO was handling their affairs. Some showed preference for more AREMA's involvement since they still acknowledged its efforts to promote productivity. MINASCO's leadership mentioned one of their biggest problem as being the lack of appropriate technology because most miners do not have the ability to purchase equipment like compressors. They also condemned the Arusha Zonal Mines Office for charging Tshs 55,0007= for the PR and CT (ordinarily worth 40,0007=) claiming that the additional Tshs 15,0007= is for surveying, which is contrary to the Mining Law because surveying is supposed to be done free by government organs. However, according to the Department of Mineral Resources at the ministry, the Tshs 15,0007= was officially introduced as survey fees to enable the Arusha Zonal Office carry out the claims pegging exercise efficiently. This was due to the shortage of funds within the department under which a lot of applications

would be piling up in Arusha. There are indications within the Government circles to expand this practice which is claimed to have shown success in Arusha to other mine zonal offices in the country.

- **The Morogoro Region Miners Association (MOREMA)** has 300 registered members (March 1996) but most of them had dispersed to other areas especially after the mine rush to Tunduru in 1995. By May 1996, there were only 120 active members. These include those with Claim Titles and Prospecting Rights. The association is run by membership fees only. According to the leadership, it has not received any material assistance since its formation. The leadership claims to have a close relationship with the zonal office. They have been given office accommodation at the zonal headquarters. The ordinary members on the other hand were quite skeptical of their leadership accusing it of selfishness, embezzlement and unconcerned with the welfare of members except when it interferes with the production process. It was alleged that MOREMA leadership is comprised of people who are businessmen and do not practice in actual production, thus they cannot be sensitive to problems facing the producers. Their interest lies in issues like marketing and pricing. The miners effective representation within MOREMA is thus very minimal and claim that sometimes they are not invited to MOREMA meetings.

In line with its responsibilities, **MOREMA** leadership claimed that it has been actively fighting for the miners' rights e.g., the Ifakara conflict with Thai miners, or condemning the government when it fails to properly address claim allocation issues. **MOREMA** has currently facilitated the formation of groups among the miners, whose sizes ranged from 5 to 10 on the average. These will be registered under **MOREMA** and each group will be given a claim. These groups will comprise both claim holders and ordinary workers. Those without claims will be advised to join registered claim holders under which they will be paid a certain percentage of the income. Any assistance will be channelled through these groups. The initiation of this group formation is a response to the first World Bank baseline study (1995) which according to the miners discussed the possibility of credit provision to smaller, formally registered groups.

In December 1995, **MOREMA** established a company named MOREMA Ltd. which has already been registered. They have applied for a "Master dealers licence" and intend to seek for partners for joint ventures. Their objective is to create a market for rubies in Morogoro in which they will be active participants. (Morogoro and Tanga region had no such markets by May 1996).

4.3.5 Association with Local government

Among the major issues which cropped up during discussions with the Local Government leaderships in the mining areas was the limitations posed on local government authorities to have complete mandate on the development of this sector. It was remarked that, the Zonal, Resident and District mining offices operate somehow autonomously of the local

administrative structures in their respective areas. Thus, apart from being obliged to attend to disputes and accidents, and some participation by a Designated Officer, (usually the District Commissioner) in registration of mineral rights, the District Executive Director has no mandate on the economic benefits accrued despite the realization that mining absorbs a significant number of the local population, most of whose basic subsistence is dependent upon the area.

Both the Geita and Morogoro District Council Offices expressed dissatisfaction on the present centralization of decision making on mining activities and the revenue accrued (royalty, taxes etc.). It was also viewed that despite the fact that the District development plans did not include the development of the mining sector, mining in Geita has always been informally recognized in terms of its positive and negative impacts to the society. The negative aspects include the destruction of the environment which has been partially addressed by the Forestry Division. The Geita District Planning Officer (DPO) noted that the District Council had proposed and submitted by-laws to the Minister responsible for local government, Ministry for Regional Administration and Local Government (MRALG) which, if approved, would allow the DED to handle certain development aspects of the mining industry and collect tax from all categories of miners within the district, individual people and mining companies.

The situation in Morogoro is more or less the same. According to the Zonal Mines Officer, mining in Morogoro has never been a district or regional administrative issue. In fact he claimed it has never been considered at those levels as a significant contributor to the economy, thus it has never featured in regional or district development plans. This is partly because all revenue accrued from mining is sent directly to the Treasury. In addition, the existing by-laws on minerals and mining activities under the district councils do only address salt mining and building minerals (e.g. aggregates, sand, and other construction minerals). These pay local taxes to the villages and District councils accordingly. He accounted that mining of gemstones did not feature in the District Management Team meetings or in the Regional Development Committees meetings. Often, district officials discuss proposals for containing environmental degradation caused by the aggregates and gravel miners on the Uluguru mountains.

4.3.6 Fabrication of Tools

In terms of local capacity for technological development, it was noted that there is some potential to respond to the needs of the miners in the country. The initiatives already undertaken include those of the Institute for Production Innovation (IPI), which has already produced a 'Retort' for amalgamation. Its acceptance rate is however still very minimal. The IPI has also identified for design and manufacturing a manual winch, an amalgamator, and water pumps. The IPI has the technical and fabrication capacities for such tasks and is in the process of identifying funding sources or sub-contracting the fabrication. Its workshops are equipped with modern lathe machines, machines for milling, drilling, frame cutting and welding. Computers and plotters enhance their designing capacity. The Small Industries Organization, (SIDO), has manufactured, according to the customer's

specifications, what they termed as a 'Gold washing machine' in its Mbeya workshop. SIDO is also equipped to handle small fabrication projects through its workshops and foundries distributed throughout the country. Apart from fabricating equipment, SIDO also has arrangements for financing the acquisition of such equipment, and has also supported the development of salt mining technology in Tanga, Lindi and Mtwara regions (equipment such as pumps, and pan construction) in collaboration with other developers. The organization is planning to privatize some of its foundries and workshops.

Although there were no workshops observed in Geita, Mwanza was found to have a number of well equipped workshops that can handle most small-scale mining needs. Workshops like those at Mwanza Engineering Ltd, Nyanza Engineering Ltd, and others, have modern equipment and the qualified human resource to carry out such functions. Matombo also had no workshops nearby the mining areas. Morogoro, on the other hand, has a number of well equipped workshops like that at Mangula, which has already participated in design and fabrication of mining related equipment such as the coal stove for both domestic and institutional use. In addition, Mzinga corporation (TPDF) also in Morogoro is carrying out tests on explosives produced specifically for mining and civil engineering works.

4.4 Other Social and Economic Considerations

4.4.1 Safety and Health

Although the study did not find enough reliable data on health and safety, it was established that the rate of mining accidents in the pits is low compared to the health hazards and illnesses occurring in the settlements. For example, most settlements were overcrowded in poorly ventilated makeshift huts. There is also lack of adequate sanitation facilities; the source of water for domestic use is the same as that for mineral processing; and crushing and grinding such as in Mugusu were being carried out within living quarters thus releasing enormous amounts of dust in the compounds. The protective gear in both mineral extraction and beneficiation, were non-existent. As a result, barefooted miners had cuts from rocks due to lack of safety boots and gloves, and some were found working under hanging roofs of open slopes without any safety helmets. In Merelani, for example, jackhammers are used for drilling without using water for dust suppression. Equally, crushing and grinding in all visited sites were all dry processes. This situation is aggravated by the fact that in almost all gold mining areas, the ore has a high silica content. Silica dust leads to lung diseases commonly known as *pneumoconiosis.*

Gold miners had direct contact with mercury. Although it has been argued that the high surface tension of mercury limits its ingestion through unbroken skin, miners usually have cuts from rocks. In addition, distillation of the amalgam carried out in open air leads to direct inhalation of mercury fumes. Underground lighting is usually provided by torches strapped around the miner's head. Apart from not providing enough light, the disposed batteries are a source of mercury. In both Rwamagaza and Merelani the pits were either poorly supported or not supported at all. Given the fact that pits are excavated from the surface oxidized zones which are usually very weak, lack of adequate support is one of the causes of pit collapses. Although the introduction of pneumatically powered drilling

machines at Merelani is a commendable initiative towards increased work performance, it has effects of noise pollution. Under normal circumstances, drillers are required to wear ear protectors.

4.5 Women and Artisanal Mining

The study noted that women's involvement in artisanal mining can be grouped in two categories; (i) those involved in mining related activities such as provision of service as housewives, food venders and in business and trade and other social amenities; and (ii) those directly involved in mineral production such as extraction, processing and marketing.

Their entry into direct production is often determined by taboo, socio-cultural factors, financial and economic capacity, technology and organizational aspects. The study established that women are mostly concentrated in mineral processing activities. Few women are involved in pit mining, for example, in reef gold mining due to its strenuous nature and the risk involved. Some taboos also limit their acess to certain activities. For example in Mgusu, women were prohibited from going to gold mining areas for fear that they would cause bad luck despite being involved in the processing activity together with men. This was not the case either in Rwamagaza or in Geita, despite having similar culture with Mgusu.

Other women's participation was influenced by marital obligations. Some women work alongside their husbands as in Mabuki and Matombo. One lady interviewed in Mabuki diamond mining area claimed that she was part of her husband's working group in which she participates as a wife, but not as an employee. It was not, however, clear how income was distributed especially because some women declined to expose the modality of sharing profits claiming their husbands were the spokespersons.

Other reasons included the need to raise individual or household incomes especially when women are compelled to enter mining to get off-farm income and increase their money earning opportunities and control as well as reducing over-dependence on agricultural production, where gains are minimal or where there is limited access to land.

4.5.1 Financial and Economic capacity

Ffew women are directly involved as claim title owners, investors brokers and dealers (Matombo and Merelani). Most of these acquired initial capital from other businesses like bars, hotels or food catering to the miners and later invested in mining. The claim title owners and investors normally provide equipment to miners on loan basis on the agreement that they are paid after production.

4.5.2 Technology

The conditions experienced in mining and the type of equipment used have discouraged women who resort to other related businesses. Underground mining, in particular, inhibits women's participation apart from taboos. Since the technology used in such mining is very

rudimentary, with little or no mechanized equipment used, most operations are risky, labour intensive and onerous as in the case of manual haulage of mineral bearing rock from underground pits, the movement of miners in and out of pits done by using hanging ropes and notches on the side walls. This type of technology has made underground mining a predominantly male activity. Accidents such as one of a lady Claim Title owner in Merelani who slipped and died while descending down her pit to check on miners alleged to be cheating on her are examples of the risks involved. Where surface mining is practiced, women can be found in processing and trading activities. This explains why there are more women in alluvial mining of river beds and banks than there are in open cast hard rock mining.

4.5.3 Organizational aspects

There was little evidence of women group formation in mining. They were employed as casual labourers in gold processing (Mgusu and Rwamagaza), and in ruby screening (Matombo).

4.5.4 Other services

Women mostly provide services and the spend-thrift atmosphere in mining settlements has made most of them vulnerable to sexual abuse and disease (especially STD's and HIV). This has mostly affected young girls and single women . However, a few have been able to attain considerable economic success through trade as in Matombo and Merelani.

5.0 ANALYSIS OF FINDINGS

5.1. Socio-Economic Issues

5.1.1 Social Organization and Division of Labour

A fundamental issue that needs to be addressed is identifying who is focused under the question of poverty alleviation. This is essential because under the current set-up, there are obvious differential dispositions and benefits accruing to the various population groups within direct or related mining activities. On the one hand, a majority of the population that enters into such production is disadvantaged i.e. children, youths, women, social outcasts (criminals, the unemployed) many of whom are forced to engage in the sector because of poverty. On the other hand, they do not only lack the capital to invest in it, but are also disadvantaged in the processes of acquiring claims to operate as entitled claim holders. They are thus at risk and are vulnerable to any dislocation that may occur.

At the same time, the informal divisions of labour that have cropped up in artisanal mining areas have been allowed to prosper. The licence or claim holder, leases all or part of the claim to pit owners who engage a team of miners while they remain in-charge of the mining operations. The claim holder in many cases is divorced from actual production processes but collects 30-40% of the earnings from each pit owner. Despite this knowledge, the claim holder is the only miner formally recognized as the miner by the Government. Other functioning groups which include miners who carry out the actual mineral extraction, and specialized gangs that carry out special duties on contracts, e.g., blasting, processing, crushing, grinding etc., are officially non-existent. As a result the following problems arise:

(i)The claim area is turned into a series of hapharzadly located pits that are detrimental to the miners' safety and the environment.
(ii) The system is exploitative in that apart from paying for the licence, most claim holders invest nothing in the area but reap the highest benefits.
(iii) The division of earnings between the claim holder/pit owner and the miners is usually determined after deducting the operating costs. There are usually no records of these costs other than a word of mouth from the sponsor.
(iv) The welfare of miners is in their own hands as they are not regarded as employees but as people with a non-binding contract with the pit owner. For example, the claim holder may decide to lease a pit to another person with hard cash on short term basis without the miners' consent. This is known as "selling a shift".

5.1.2 Employment

Artisanal mining can be seen as an avenue for raising living standards through offering opportunities for gainful employment in the rural areas. It allows for a high degree of flexibility and may fit in with the seasonality of other economic production activities e.g., agricultural production and businesse. Artisanal mining has also provided a significant source of employment to women, youths and the unemployed rural population. However, to a majority, it is an unstable source of employment, depending on the availability of minerals and/or production levels and the government regulatory environment in addressing

the sector. Child labour was also witnessed mostly in mineral processing activities. Although some of the children admitted that they are attracted by visions of big money, it was seemed that most of them are compelled by the need for money for their families, while others are actually encouraged by their elders.

5.1.3 Income

It was very difficult to establish a monthly rate of income for this sector because it all depends on successful production of minerals and also because the miners neither have data nor provide returns on production, or submit under stated production figures. Nevertheless, it was established that the incomes from successful activities are quite significant although they vary according to area, type of mineral and the number of people involved. In most cases, incomes are unequally distributed among those engaged in production and the claim holders. In this respect, a majority of the mining population are still deprived economically and become trapped within the production system in expectation of breaking even in future.

According to the miners, income realized from gold mining can be between TShs. 300,0007= and 1 million per production season per miner. Judging from the distribution system of income or produce, this implied that the claim holders benefited more in monetary terms. In the diamond mining areas, incomes were more erratic in comparison to gold production and rubies. The normal income was about TShs. 500,0007= to 1 million per six months period per person. The incomes of Merelani and Matombo are incomparable because of the very nature of gemstones themselves, the difference in mining and processing techniques, application of mechanical tools, etc. However, judging from material accumulation, the incomes in Merelani are substantial. For example, some of the miners have been able to purchase compressors worth TShs. 14-19 million. In Matombo, the dwindling market of their rubies, plus the shortage of water for processing at certain times reduce the earnings substantially. Despite this, the miners acknowledge that it is still a worthwhile undertaking compared to other rural income generating activities.

Furthermore, in many cases, incomes from mining have been sufficient for household sustenance and as capital for other businesses and purchase of assets. It was noted that much of the development in infrastructure in mining areas owed its status to mining. For example, Merelani, Rwamagaza and Mabuki are typical mining villages now developed into permanent settlements. Estimates of average incomes per production season in different mining areas is shown in Table 5.1.

Table 5.1: Average Incomes per production Season

Mine Site / Mineral Commodity	Average Monthly Production	Value in Tshs (Million)	Claim Holder Share (%)	Pit owner/ Miners share (%)
Mgusu/gold	150 gms	0.64	30	70
Rwamagaza/ gold	360 gms	1.5	30	70
Merelani/ Tanzanite	n/a	n/a	70	30
Mabuki/ diamond	n/a	n/a	n/a	n/a
Matombo/ruby	n/a	0.2	30-50	70-50

5.1.4 Poor accounting and financial management systems

Poor accounting and financial management systems have limited the capacities of the miners to invest in profitable ventures. This situation is aggravated by lack of banking services and/or lack of appropriate information on how to invest. Miners also shift periodically in search of greener pastures especially due to lack of technology. For example, lack of mining knowledge and adequate technology limit their ability to mine deeper which in turn makes formal control of the operations and hence the collection of the economic rent, more difficult.

5.1.5 Vulnerability

Vulnerability is an important dimension of poverty in artisanal mining basing on the 'delicate' social and political environment the miners operate in. Conflicting property (land) ownership policies render small miners vulnerable to dis-ownership when bigger or state interests overrule rights in the guise of compensation which is hardly worth the property, or the discrimination in offering prospecting rights to otherwise publicly owned land. Even under the current liberalized system where miners have to enter into negotiations with bigger companies interested in their areas, the idea of a fair game, is still far fetched. While big companies have the capacity to engage lawyers, engineers, economists and other professionals in negotiations, most artisanal miners do not have that capacity and can hardly understand, interpret or sometimes even read the negotiated contracts. As a result, most miners use their instincts to either accept a raw deal, e.g., miners in Mabuki, or just reject the offer, e.g., Rwamagaza miners and East African Mines Ltd.

5.2 **Institutional Aspects**

It was established that the Government institutions, including the MRD of the MEM have failed to cope with the rapidly expanding artisanal mining activities in the country in terms of the provision of technical, regulatory and financial assistance. The coordination of functions and responsibilities between the zonal and resident/district offices often lags behind the need for mining rights and technical expertise. These deficiencies have impeded the creation of a suitable environment for the development of artisanal mining. In addition,

the Government has not yet devised an equitable system of transfer of revenue accrued from the mineral economic rent between the central and local government. There is thus failure to channel locally realized resources into local development, hence one finds districts like Geita which have been the "gold - pots" of the country for long lagging behind in terms of local infrastructural development, despite their significant contribution to the National economy. Majority of the people cannot therefore access basic facilities.

5.2.1 Property Ownership Rights

There are a number of constraints resulting from legislation or inefficiency in the implementation of existing law or policy directives. The first constraint is Property Rights. Land ownership is the most significant problem in the development of artisanal mining. There is a lot of conflict generated by existing legislation causing confrontation between the Government and the people in most of the areas where artisanal mining is practiced. The major causes are traditional v/s modern interpretations of land rights to which compensation is warranted, and some mining rights overriding other land ownership rights. The demarcation or mapping of mining rights operate irrespective of any other ownership rights, despite the Government's claim to protect the rights of small holders from land ownership conflicts.

The study revealed that there are many factors which give rise to the cnflicts in ownership rights. At one level it can be summarised as a misconception on the part of the miners on legal ownership or mining rights vis-a-vis the existing land policy, and, the lack of will to compromise. For example, with respect to land conflicts in Mabuki, the Mwanza Lands Officer contends that Mabuki was surveyed following complaints from the village government and compensation was worked out accordingly. Most villagers who used to farm in areas allocated to large scale operators confirmed having been given compesnation but claim to have been offered a raw deal. On one hand, the miners claim to have legal occupation of their present working areas, especially because the land have originally been their farmland where they produce food crops. On the other hand, others claim to have purchased the land from the villagers through compensation. The village government admits a recognition of these operations and insist that they should be at least consulted on land allocation, whatever its use.

5.2.2 Policy Issues

It is the policy of the Government that artisanal mining areas be limited to indigenous Tanzanians only. As such, foreign investors are not allowed to operate in these areas unless there is a transfer of mineral rights. It is also the Government's policy to encourage access to appropriate technology and finance by artisanal miners in a bid to transform their activities to more organized operations. It is the view of this study, that these policies are contradictory and thus self defeating despite the good intentions. Mining, small or large, is a capital intensive undertaking and thus beyond the capability of most indegenous Tanzanians. The criteria upon which special areas for artisanal mining can be set-up is technically questionable. In addition, setting up such areas denies artisanal miners the opportunity to access both finance and technology through joint venture partnership.

5.2.3 Tenure Period

Mineral Rights for artisanal miners are issued for a period of one year which is limiting especially when miners try to obtain loans or go into joint venture partnership because of one year is not enough for loan repayment and there is no guarantee for the renewal/extension of mineral rights ownership. Furthermore, the period used for negotiations for loan aquisition or joint venture pertnership, takes a big chunk of the one year mineral rights tenure period.

5.3 Organizational aspects

5.3.1. Marketing

There are currently many deficiencies in the marketing system which have direct implications on the artisanal miners. Firstly, there are limited opportunities for marketing within the production areas. The 1993 NBC decision to stop purchasing gold from individual miners has contributed to the expansion of 'illegal' mineral dealers and hence there is minimal collection of revenue in terms of taxes or royalties paid. Secondly, the prices offered are too low compared to world market prices, a situation which discourages the miners thus resorting to informal marketing channels. For example, at the time of the study, the price offered by the banks was Tshs 4500/= while that offered by the parallel market varied between Tshs 6000/=-7000/= per gram. The world market price for gold was around Tshs 75007= per gram. This, coupled with difficulties in collecting tax from the artisanal miners due to the nature of their informal and transient activities, accounts for the meager revenue accumulated from mineral extraction.

Poor marketing information system add another difficult dimension. Tanzania Mineral Dealer Association has introduced auctions but it has not yet provided a system of marketing information on pricing, market availability and technical advice on quality, etc., to the miners and their associations members.

5.3.2 Cooperatives and Associations

The Regional Miners Associations (REMAs) indirectly assist Zonal and Regional offices in overseeing the smooth functioning of activities, particularly when it touches certain interests, e.g., if it interferes with the accomulation processes. Currently, however, the REMAs' representation of the miners has declined due to conflict of interests between leaders and members. The leadership often fails to identify themselves with the miners and put emphasis on their business interests rather than being engaged in actual mining. Other reasons include lack of operational funds. The Association operates basically using members contributions (fees), and because miners have gradually lost confidence on their leadership, there is a decline in membership and contributions. Most REMAs have no other solid sources of funds. In some mining areas, independent associations have been established after experiencing disappointments with REMAs e.g., Merelani-Laisinyai Cooperative - MINASCO. Others have formed small working groups especially after the

information that credit could be more easily channeled through such cooperative ventures, i.e. Mabuki-Misungwi, and Matombo-Morogoro..

The major factors leading to REMAs failure are:

- the mode of establishment of these organizations which was a top-down approach after being initiated by the Government,
- the nature of their membership;
- the lack of determination by miners to collaborate. The implications of this is lack of representation of the miners interests and loosely organized activities. Consequently, the REMAs have failed to act as an effective coordinating organ between the Government and the miners in promoting the sector. The establishment of voluntarily associations e.g., MINASCO in Merelani is a reaction to this failure. Other associations include The Federation of Miners Associations, (FEMATA), formed in 1984. It does not however, have office accommodation although in January 1996, fresh leadership was elected to the top posts. The Tanzania Mineral Dealers Association (TAMIDA) formed in 1989, was basically established as a link between the Government and the miners for marketing purposes. It was also supposed to offer technical advice on mineral marketing to the Government. TAMIDA is however not very favourable amongst miners particularly because most dealers have taken advantage of the ignorance on mineral quality prevalent amongst the miners by cheating or lowering prices in auctions, to their own (dealers) advantage.

5.4 Technology

5.4.1 Mineral Extraction

The problems associated with mineral extraction were noted at every level of artisanal mining. These are associated with lack of technical know-how, lack of appropriate working tools and technology, chronic shortage of capital and other socio-economic problems. There is also lack of information on different technical issues associated to mineral extraction. In most cases miners do not even know where to go in search of help. The problems associated with mineral extraction that were observed include the following:

(i) Miners have no knowledge of mineral extraction methods that are suitable for the type of rocks and geological conditions in the locality.

(ii) There is an obvious lack of geological information on the area, thus, the depth, width, inclination, grade, etc., of the orebody are not known. This is aggravated by the fact that miners do not usually conduct any feasibility study prior to the commencement of production. Normally, conditions of the surrounding rocks are detected during production which is usually too late to take affirmative action.

(iii) In most sites, where mechanical equipment have been introduced, e.g. Merelani, they are inadequate for the job as they are not linked to production capacity. As a result, there is under utilization of the equipment.

(iv) Location of pits is done hapharzadly without any technical consideration thus endangering their stability. Pits are located within the zones of influence of others.

(v) The sizes of pits are too small to warrant arrangement of a formal shaft, i.e. with manway, hoisting chamber, services, etc.

(vi) Where supports are used, they are inadequate and in most cases no supports are used, e.g. in the weak laterites of Rwamagaza. In addition the high cost of timber (logs) encourages mining without support.

5.4.2 Mine Ventilation

Problems associated with mine ventilation include:-
(i) Lack of adequate ventilation which has sometimes lead to fatal accidents, e.g. suffocation by CO gases at Mgusu. Even in shallow pits that could make adequate use of natural ventilation, the lack of knowledge inhibits its use.
(ii) Expensive equipment like compressors are used to ventilate deep pits e.g. Merelani. Apart from being an expensive way to ventilate a pit, a substantial amount of moisture is added into the mine air.

5.4.3 Tramming and Hoisting

(i) There is not a single mining site that has got rid of manual movement of ore from the face to hoisting point. As a result, a lot of ore and waste rocks are stocked underground unnecessarily. This complicates both miners and material movement and ventilation, (ii) Although some mechanical equipment has been introduced, e.g. at Merelani, the majority still hoist the broken rocks manually. As a result tramming and hoisting constitute one of the major delay points of the production cycle.

5.4.4 Water Problems

(i) Once mining has reached the water table or encountered any underground water, most operations are suspended due to lack of pumping equipment. The common approach of using a bucket and rope for dewatering is inadequate.
(ii) There is an acute shortage of water during dry season which reduces washing activities. This is also attributed to lack of pumping and water storage facilities.

5.4.5 Mineral Beneficiation

Mineral Beneficiation problems identified are classified in two categories namely, inadequate equipment and lack of knowledge.
(a) *Mineral Beneficiation Equipment:* The equipment problems identified that contribute to low throughput and recoveries are divided into the following three categories: (i) The crushing and grinding equipment (mainly for primary ores); (ii) The classification and screening equipment (sizing); (iii) The mineral separation or sorting equipment.

(a) **Inadequate Knowledge on mineral beneficiation process and principles:** It was noted that although artisanal mining involves the conventional processes such as crushing, grinding, classification, separation, etc., the knowledge of mineral dressing and metallurgical principles involved is inadequate.

Some examples include;
(i) Gold miners' rejection of the use of simple retorts for mercury distillation after amalgamation for fear of loosing the gold in the retort.
(ii) Miners complained of difficulties in solving amalgamation problems especially on cases where gold does not fully amalgamate with mercury.
(iii) Miners' complaint of being overstrained with inefficient screening (e.g., loose sediments with high clay content at Ng'ongolo, Matombo). Despite the fact that screening^ of gravel is done manually, there is lack of water at certain times of the year such that the initial removal of mud/clay is done with muddy water which may lead to losses of gemstones. In addition, conducting screening with a sticky feed, e.g., with muddy clay, results in blinding of the screens which leads to poor results.
(iv) There is lack of interest or know-how from miners at Merelani to recover smaller gemstone particles contained in mined materials which are a result of using blasting during underground extraction. Interviews with Tanzania Gemstone's Gemologist revealed that gems under two carats are found in waste material in fair quantities despite their being marketable. The large stones that have no internal flaws or inclusions are rare though highly valuable. In addition, miners decline or are not able to process the gemstones further after sorting as a means of increasing their values (value added measure),
(v) There is little consideration or awareness of the seriousness of the hazards accompanying the use of certain dangerous chemicals like mercury. The concentration of mercury in water samples around Lake Victoria Goldfield mining areas indicate serious pollution with figures above permissible levels, e.g., figures recorded by Ikingura et al., (1994), range between 0 - 32.6 micrograms per litre with a mean of 8.9 micrograms per litre. Permissible levels in drinking water according to WHO standards should not be more than 1.0 microgram per litre. Furthermore, miners could be seen handling mercury casually with bare hands, heating the amalgam in open air and thus releasing the mercury vapour to the atmosphere. There is also direct inhalation of this vapour by miners. Besides, mercury is kept in open containers thus allowing it to evaporate easily.

5.4.6. Environmental Problems

Environmental Problems associated with mining are usually categorized into direct and indirect ones. Indirect effects, e.g., the food chain effects, require detailed scientific investigations which were beyond the scope of this study. In this respect, direct effects which could be visually observed in the field are discussed here.

(i) Land Disturbance and Degradation

The excavated pits and dumps of rubble left behind after mining had ceased were observed to cause severe land degradation. As the pits and piles of rubble become obscured by grass, these areas become dangerous to both people and animals and thus a loss of grazing land. Some abandoned areas in Rwamagaza provide a good example. In addition, agricultural

land is lost due to blanketing of the top soil with the waste rocks. The high demand for wood for construction and support leads to an irretrievable loss due to deforestation.

(ii) Hydrological Effects and Water Pollution
Siltation problems as a result of the washing of ore on river banks were too evident, especially in gold mining areas. Uncontrolled alluvial mining adds to siltation, destruction of river banks with consequences for accelerated erosion, flooding and change in drainage patterns. Although the mining at Mabuki in Mwanza Region cannot be categorized as alluvial, the nature of the terrain where mining is carried out and the washing method used, are good examples of the above problem. Chemical pollutants especially in gold mining areas where chemicals like mercury are widely used, are a cause for concern.

(iii) Air Pollution
In almost all artisanal mining areas visited, the addition of dust into both surface and underground air was observed. Underground drilling, ore loading, surface crushing and grinding are all dry processes generating enormous amounts of dust. Whilst long exposure to any respirable dust is very dangerous to one's health, the exposure to silica dust, e.g., those mining reef gold where rocks have a high silica content, cause serious lung diseases, e.g., silicosis.

(iv) Other Effects
Other allied problems include the uncontrolled blasting in areas like Merelani leading to noise and vibration disturbances. In most sites there is an obvious destruction of the natural beauty due to the distressing sites left behind by hapharzadly located pits and piles of rubble.

5.5 General problems

In addition to the above observed problems, there are others related to establishing an appropriate working environment which combines the limited organizational, institutional and technical aspects related to technology in artisanal mining as follows:

(i) There is an obvious lack of technical advice to miners on sensitive issues like health and safety, transportation and storage of explosives, mine support systems, etc. In addition miners usually do not know where to go for consultation purposes.
(ii) Mine site inspections are very rare and when done they are too casual to have any effects.
(iii) There is a clear lack of information pertaining to geology, marketing facilities, equipment, safety matters, etc.
(iv) There is a complete lack of training facilities and programmes for the miners.
(v) Although most working tools are fabricated on site, facilities available for this job are inadequate. Artisans innovativeness could be enhanced through formal/informal training.

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5.6 Some Positive Trends

Rural development conceived in the form of the mushrooming of rural townships or peri-urban settlements is also attributed to artisanal mining activities. Most mining settlements start initially as mining camps with temporary shelters, giving the impression of lack of permanence to warrant significant capital or infrastructural investment. This is so because often, most miners are driven by the quest for wealth. They travel long distances or even cross borders into foreign countries responding to 'news' about mineral discoveries. Temporary shelters thus become the most immediate manner of settling down within the new exploit. However, experience has shown that some of these camps develop into permanent settlements or villages, for example, Ifakara, Mgusu, Mabuki, and Merelani. The people invest basically in personal property like housing, transport and other businesses within the settlements or in their areas of origin. Services normally follow, e.g., health and education sometimes as a response to government intervention (e.g., in Mgusu), and other services like food supply, which add to the permanence of such settlements.

6.0 HYPOTHESES TESTING

The data and analysis presented in this report bring up technological issues related to mining. It was also found imperative to identify other factors that influence the technological environment in relation to poverty alleviation within the artisanal mining community. In this regard, socio-economic factors, organizational and institutional aspects were also explored. In conducting this study, five hypotheses were postulated so as to sharpen our focus on key elements of the study. The results of the tests of the hypotheses in relation to this study are as follows:

(1) The working methods in all visited sites are labour intensive and utilize inferior working tools most of which are fabricated on site. Despite some mechanisation, manual drilling is applied by miners who cannot afford a compressor and a drilling machine. By comparing these two groups, it was found that those with mechanized drilling can drill and blast 8 (eight) times the number of holes compared to those using manual means. In addition, ventilation of pits by using a compressor reduces the re-entry time after blasting to one hour compared to 24 hours for those depending on natural ventilation. Except for one pit in Merelani which uses a winch for hoisting broken rock to surface, all either use manual means and have been abandoned due to problems associated with mining deeper. Miners' earnings are directly related to the amount of tonnage processed. These trends establish clearly that **there is a direct relationship between the application of technology and increased productivity.**

(2) The 'mine workers' who were organizationally and economically disadvantaged were subjected to production without any basic technological investment mostly because the source of finance was in most cases informal, and most investors are more interested in profit maximization with minimum costs, at the expense of the miners dismal situation. It was further observed that the social deprivation and illusionment are the major factors influencing the miners decision to engage in mining activities. Having no better economic option, they become subject to exploitation with little choice on technology. This is in agreement with the assumption that **the nature of the social and economic environment has a bearing on the decision for technological application in the production process.**

(3) It was further observed that the artisanal mining sub-sector has its own divisions of labour which accommodate the production processes, but whose organizational framework is not officially recognized by the government. There is thus much leeway for exploitation to the detriment of those who do not own the means of production, i.e., the mineral right. For example, a Claim Title owner could sub-contract pits to other individuals without the consent of the involved miners, an act known as 'selling a shift' mainly because there is no contractual obligation between the CT owners and the miners. The distribution of earnings is also dependent on what the pit owner decides to declare as incurred operating costs. Thus, **the organization of production determines the nature of the miners' environment and hence their opportunities and constraints.**

(4) In all gold mining areas the amalgamation process releases mercury to the atmosphere and washing ore on river banks discharges metal mercury into rivers. The manual crushing, grinding, drilling and loading of ore, generate enormous amounts of dust which have severe health consequences. There are also other health hazards associated with working underground with no support gear and lack of proper ventilation. Furthermore, the miners did not seem to know the technologies and the associated dangers of some processes they used. Thus supporting the argument that **lack of information and adequate knowledge on mining technology influences the level of production and the risks involved.**

(5) The assumption that **the absence of a coherent institutional framework concerned with mining has affected the nature of miners' work environment and hence their earnings** is justified by the prevailing lack of basic supportive resources to enhance mining productivity. The lack of resources, unavailability of extension services, and lack of institutionalised finance and credit facilities all affect the miners' working environment and hence technological advancement. The limitation of artisanal mining activities to Tanzanians only also limits the miners' access to finance and technology to lack of possibilities for joint ventures. The one year tenure period of mineral rights does not only act as a disincentive to investors but also makes artisanal miners feel insecure and hence reluctant to make long term investments.

7.0 EMERGING POLICY CONCLUSIONS

This research has looked at various aspects that have a significant bearing on the levels of technology applied in artisanal/small scale mining. The socio-economic, organizational and institutional factors determine the patterns of access and use of appropriate technology for miners. Appropriate technology has three basic qualities: adaptiveness, effectiveness and efficiency. While general technological development may be aimed at enhancing effective and efficient production, the adapriveness of appropriate technology ensures its relevance and sensitiveness to the environment within which it is (to be) applied. Availability is another important consideration as technological choice would take into account the socio-economic situation of the user. Finally, the policy for developing appropriate technology should accommodate an expansion and development for constant improvement and adaptiveness in a changing environment and more efficient technology.

Before any solutions can be provided, the miners need to be educated and sensitised on various aspects of mining and the environment to appreciate the monetary and other non-monetary benefits associated with staying longer at one place. They can enhance their mining capabilities by ensuring easy access to appropriate working tools and technology, markets, financial and credit facilities. This could provide the remedy to current negative social and environmental impacts that result from poor working methods and tools and beliefs.

The achievement of the above can only be realized by putting in place policies formulated specifically for promoting the artisanal/small-scale mining sub-sector. Such policies should not only aim at maximizing revenue flows to the government, but also transforming the artisanal operations to more organized operations. Policy issues related to artisanal mining technology and their areas of influence that fall within the scope of this study are suggested as follows:

7.1 Legal Ownership

It was observed that most of the problems within the artisanal mining sub-sector emanated from the unregulatory and informal nature of the sector itself. For instance, some of the miners have neither legal nor formal identity, a situation that excludes them from the target group in relation to support or intervention. Furthermore, in this context, the sub-sector deprives the government of the revenue it deserves. Hence, it is recommended that: (i) The Government should streamline processes of licensing to facilitate the acquisition of prospecting rights and claim titles in order to ensure identity and the responsibility to invest in production. This would not only facilitate the role of the Government as a regulatory system, but also carry out the monitoring which would provide a basis for the provision of credit and training for the miners.

(ii) The size of the claims issued to artisanal miners should be pegged to "ability to develop". What is observed in the field are harphazardly located pits as a result of people being located bigger plots than their abilities to develop them. As a result, they resort to

renting part of the claim leading to hundreds of pits. The Merelani experience (1995) provides an example of giving legal ownership titles commensurate to the capacities of individual miners to effectively operate in a given area.

7.2 Capacity Building

The weaknesses in REMAs could be mostly attributed to their lack of representation of the miners' interests. There is thus a need to enhance the capacity of REMAs to enable them to support their members effectively. In addition, efforts should be made to promote formation of miners' associations based on shared interests. This study has shown that some REMAs, e.g., MWAREMA is not recognized by the diamond miners of Mabuki who recognize it as a gold miners' association. It is recommended therefore that the Government should formally encourage and facilitate the establishment of miners' groups based on voluntary collaboration, sharing of common interests and common goals. These groups or associations should be free to collaborate with any local, national, Governmental, non-Governmental or private organizations in promotion of their interests.

7.3 Financial Support and Credit

Promote access to loans and equipment leasing programmes through the establishment of special credit institutions, while ensuring that they offer interest rates which are affordable and reasonable to artisanal miners. This could be done through the following processes:

(i) Encourage financial houses and banks to employ mining experts who can help in assessing the potential for availing financial services to the mining sector;
(ii) Introduce special funds that could be administered on commercial basis with reduced interest rates; For example, a percentage of the revenue from artisanal mining may be channelled to fund a government controlled revolving fund to be re-channelled to support artisanal activities in terms of credit or equipment support.
(iii) Encourage miners to use mining experts to assess ore reserves in their claims so that their mineral rights can be accepted as a collateral while seeking loans. In addition, the tenure period of their mineral rights should be increased in order to make them financially attractive.
(iv) Explore ways of lending without collateral e.g., through the formation of solidarity groups and third party guarantees in order to minimize the risk of losses. This could be done by working with NGO's.

7.4 Marketing

The current marketing systems have inherent weaknesses that have contributed towards illegal mineral trading all over the country. Apart from the bureaucratic procedures that discourage a lot of mineral traders from declaring true values of their traded minerals, lack of marketing information and formal credit schemes have contributed to denying the Government the deserved revenues. Therefore, it is recommended that the government should make deliberate efforts to reduce the amount of paper-work dealers have to endure, facilitate availability of marketing information, improve miners' marketing knowledge

through training schemes/extension services, facilitate and encourage financial institutions to provide credit schemes. Extension services in marketing should also cover areas like educating miners on minerals valuation and grading, promotion of mineral auctions in collaboration with associations like TAMIDA and other NGOs. Whilst strengthening the moniioring and record keeping systems that would enhance control over parallel markets, efforts should be made to encourage mineral dealers to acquire licences. For this to succeed, licensing procedures should be made less bureaucratic.

The licensing of brokers must have earned the Government a lot of revenue which originally went through illegal channels. However, there is need for review of the overall procedure. There is need to strengthen security at production points, to minimise smuggling. In principle, it is the obligation of the Claim Title owners to monitor but there is justification to urge the government to review the operating procedures of brokers and strengthen the monitoring system. This may be in the form of allowing them to operate as individuals as it is at present, or as agents of dealers or producers.

7.5 Monitoring and Coordination

There is a need to decentralize certain functions of the MEM to the Zones and regional administrative offices to facilitate the overseeing and monitoring of artisanal mining activities. It is recommended that the Government should re-categorize the control of mining activities and revenue from a centrally based approach to include more decentralized interpretations. This could be done by involving the zonal and regional mining offices, and local governments up to village level.

7.6 Training

The miners' lack of knowledge as regards the extraction and processing techniques, safety measures, mining regulations, marketing techniques, financial and credit facilities, as well as some beliefs that hinder development were observed. It is important therefore that training programs should be arranged in order to provide miners with the necessary prerequisite skills for the industry.

Both formal and on-the-job training can be organized through the mines zonal offices such as through extension services and private trainers. A good example, is a one-day on-the-job training on mine safety which was organized by the Geita mines resident office for miners at Mgusu. Seminars on specific issues should be encouraged and carried out in mining areas for easy access to miners. Experts on specific areas could be invited to speak in these seminars.

7.7 Environment

The country lacks a coherent policy on environmental management which integrates the various sectors concerned with environmental issues. It is important that all ministries dealing with Land, Forestry, Agriculture and Livestock, Wildlife and Mining work together in regulating mining activities. Ministries such as Lands, Agriculture, Livestock and

Cooperatives with technical and extension capacity related to environmental management, should be utilized in providing those services to artisanal miners. Furthermore, there is a need to balance the exploitation of all natural resources for the benefit of all mankind. It is not necessarily true that a mineral resource in a forestry reserve is always more valuable than the forest reserve itself taking into consideration economic, environmental and other aspects.

Toxic chemicals like mercury, cyanide, etc., continue to be used unabated. The effects to the environment, not only resulting from the used chemicals but also as a result of inferior working techniques, are already too evident. Land degradation, accelerated erosion, obscured pits that pose danger to both humans and animals and affecting the aesthetic conditions of the environment, are common features in most artisanal mining areas. Thus, for adequate management of all natural resources, it is recommended that:

(a) There should be coordination an established integration between the various relevant institutions dealing with natural resources. This can be in the form of coordinating training, awareness, monitoring and regulating programmes.

(b) Efforts should be made to put in place an integrated environmental mining policy that would provide guidelines on:

(i) Discharges of mining waste to the ground and water bodies;

(ii) Air pollution control;

(iii) Importation and use of toxic chemicals;

(iv) Health and safety, etc.

(c) Environmental indicators should be put in place so that the set standards and regulations can be easily enforced through monitoring and inspection.

(d) Regular monitoring programmes should be organized through existing zonal and district/resident mines offices. For this to succeed, adequate resources in terms of trained manpower and working facilities should be made available.

(e) Over time, as miners' awareness over environmental issues is raised, plans should be made to peg certain standards to the renewal of mineral rights. Past records provided through the monitoring programme over individual licences should be used in this exercise.

7.8 **Availability of Technical Information**

Interviews with miners on matters related to their work, e.g., on availability of markets, credit and financial facilities, geological data on their areas, etc., give a clear picture of their lack of information. Availability of mining related information would enhance miners' efforts in running their day-to-day activities. It is therefore recommended that the government should develop special programmes aimed at providing information to miners. For example, designing simple drawings and leaflets in Kiswahili, visual aid facilities like cartoons and films to the miners. The radio is one of the communication media that miners have access to. Therefore, special programmes on specific issues can be disseminated to a wider audience so as to create mining interest to the non-mining community.

7.9 Equipment and Working Tools

The availability of appropriate working tools is one of the most important aspects in improving miner's productivity. As seen in the field, almost all activities are either carried out manually or by using inappropriate tools. In addition, there are no direct tools-supply channels so that those financially capable could purchase them. In order to improve the miners access to appropriate equipment and working tools, the following is recommended:
(i) To encourage local engineering institutions, entrepreneurs and workshops to adopt, design and develop appropriate tools taking into considerations the local working environment. This report identifies what it regards as suitable tools for artisanal mining. However, a more detailed technical audit that would cover the major and active mining areas in the country and that would include all mineral commodities should be conducted. This should, where possible, involve institutions that are active in technological innovations and those that are in the vicinity of these mining areas so that interests can be developed through direct assessment of the market potentials.
(ii) To strengthen and provide support to fabrication units that exist within the mining areas. This can be done through training, provision of loans, etc. Training could start by identifying existing fabricated equipment and tools and giving demonstrations on how to improve the designs and their fabrications.
(iii) Promotion of hire/purchase schemes on mining and processing equipment. The Government should take the initiative to encourage NGOs and local entrepreneurs to take part in the exercise.
(iv) To encourage the provision of centralized services, especially mineral processing facilities. Examples exist in the country, e.g., DEMCO mine in Chunya provides complete gold processing services to artisanal miners through an agreed sharing system. One of the sharing systems is when the miner leaves the tailings behind after amalgamation to which the plant owner uses cyanidation to recover the remaining fine gold.
(v) Where necessary, to provide clear importation channels for mining and processing equipment. Incentives could be provided without discouraging local manufacturers.

Details of recommended artisanal and small-scale mining equipment and tools regarded as appropriate under the presented working conditions, are presented in Appendix I.

7.10 Use of Explosives and Other Hazardous Chemicals

Although not in all mining sites, there was an indiscriminate use of explosives in most of the visited sites, i.e., Merelani, Matombo and Rwamagaza. In all these areas, there was no regard for safety rules as required by law. This could be attributed to the miners ignorance of the mining laws, lack of know-how and the Mineral Resources Department's inability to implement mining laws. In Merelani miners even boasted that one doesn't need a licence to handle explosives. Based on this, we would recommend that:
(i) The Government should ensure, through zonal and district mining offices (using trained mine inspectors), that the current regulations regarding the handling, storage and use of explosives, are being observed by miners.
(ii) The distribution of explosives is strictly through authorized agents who should in turn ensure that they are sold to licence holders only.

(iii) Explosives storage facilities for small users should be made available through mines offices. In addition, designs of these boxes should be made available and mine inspectors should inspect and approve privately built storages.
(iv) In order to encourage miners to acquire blasting licences, special training programmes on explosives handling should be conducted in mining areas.
(v) It is also recommended that the government should regulate the importation, distribution and use of dangerous chemicals like mercury.

7.11 Energy Sources

Lack of adequate sources of energy is one of the problems that makes artisanal mining so dependent on labour intensive techniques. In addition, the available sources are either too expensive for the miners to afford (e.g., electric generators and internal combustion engines) or are too far from the mining areas, e.g., the electric grid system. With this in mind, it is recommended that efforts should be made to encourage research in affordable sources of energy by taking into consideration the remoteness of most mining areas. Such sources include, solar energy, small hydro-based plants, wind energy, water wheels, etc. Research institutions should be encouraged to direct their efforts to search for cheap energy sources the outcome of which might have far reaching benefits. Detailed recommendations on energy sources regarded as appropriate for artisanal and small-scale mining, are presented in Appendix II

8.0 EXPECTED OUTPUT AND BENEFICIARIES

This research programme provides a clear indication of technological problems facing the artisanal mining sub-sector and points out what needs to be done to alleviate these problems. It also provides a clear assessment of the local capacity in solving the identified problems, and where necessary, indicates the need for importation of technology and their sources. Local capacity for fabrication of working tools has been identified. In turn this will provide miners with appropriate and reliable environmentally acceptable technology technology that will improve their working conditions and revenue earnings.

Technology that is being used in other countries under more or less similar conditions that can be adopted here in the country has been identified (see appendix I. Recommendations for schemes like the hire-purchase of equipment to miners is bound to have effects on both the miners who cannot afford to buy these equipment directly and to companies wishing to provide these services.

This study also provides strategies through which information on geology, mining, processing and associated technology, markets, loans, credit facilities, etc., can be made available to miners. This will enhance their understanding of their working environment and thus improve their earnings. The An analyses of Socio-economic aspects is provided and it establishes their linkage with technological problems. This will complement previous studies on the topic, and, provide another framework for reference for policy makers and functionaries concerned with the development of artisanal mining.

Finally, the study lays a foundation for action-oriented research or direct tackling of artisanal mining problems. Consequently, it provides local research institutions and others with agenda for solving artisanal mining problems with the required information and a working basis.

9.0 FURTHER RESEARCH

Following this study, further research work proposed to be done include;
(1) **An action oriented research:** This seems necessary and should be carried out in collaboration with an engineering institution and a workshop. The work should try to implement the working methods recommended by the current study, help to improve* fabrication capacities of miners, carry out designs, production tests and demonstrations of various recommended equipment;

(2) **Provision of information to miners:** The new research should follow up this with the government and other donors to support specific educational programmes directed to artisanal miners. Production of leaflets, organization of seminars, etc., should form part of the action oriented research;

(3) **A detailed study on women's role and status in gold and precious stones mining** should be done to establish the strategies which are appropriate for reaching women in this sub-sector.

(4) **The child labour problem:** Due to the limited scope of this research work and the budgetary constraints, the problem was not explored at length. It is therefore recommended that a research programme be carried out to explore the causes and ways of tackling this problem.

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APPENDIX I

Recommended Equipment and Tools for Artisanal Mining

Having identified the policy issues related to provision of equipment and working tools, it is imperative to provide guidelines on which equipment are regarded as appropriate for artisanal mining operations. In identifying such equipment needs, consideration has been given to the remoteness of most sites and hence lack of dependable power supply. The fact that most artisanal mining areas have no access to the national electric grid system and the investment and running costs of electric generators are beyond most artisanal miners' reach, makes electrically driven equipment unfavourable. However, options for those who can afford generators should be provided.

(a) Mineral Extraction Equipment

(i) Hard Rock Breakage

This would require drilling machines. A pneumatic jackhammer powered by compressed air and with a separate feed line for water supply would be appropriate. Wet drilling should be encouraged for underground work due to limited ventilation. Surface drilling could work without water lines. Underground machines would require a telescopic jackleg powered by the same air line as the machine.

The operation of these machines require the following accessories:

1. Compressors - usually piston, axial-flow or turbo compressors with capacities 7-8 cubic metres per minute of compressed air. Portable compressors with diesel engines are suitable for artisanal/small-scale mining operations.
2. Drilling rods - (0.8m-2.4m lengths) and diameters of 32-34mm. Drilling rods with chisel bit heads are recommended for their easiness in handling.
3. Pneumatic grinders - for repeated sharpening of drill bits (this can be centralized). The gasoline powered hammer drills are not recommended for underground operation due to environmental and safety problems. However they can be used for surface operations although the problem of ensuring they do not find their way underground, makes them unfavourable.
4. Compressed airlines - PVC pipes are more suitable for artisanal workings. In addition, rubber hoses are necessary for connections between the machine and the main line. Water lines on most jackhammers are usually 13mm and air lines 25mm.

(ii) Hydraulic Mining

In mining of most alluvial deposits, heavy mineral sands and other soft rocks, a technique known as gravel pump mining is recommended. It needs large quantities of water for both hydraulic mining and transportation. Suitable deposits are the non or slightly consolidated host rock and limited coarseness of granulation suitable for pumping (Hentschel, 1993). The large amounts of sediments produced may cause environmental concerns. A diesel driven pump with throughput capacity of 20-100 cubic-metres/hour is recommended. Water jets or monitor loosens the material which is then pumped in a slurry form by a gravel pump to the beneficiation area.

In alluvial mining areas with water shortages, e.g. Ng'ongolo, Matombo, which also has thick overburden, a solution is to use a stripping machine (e.g. scraper loader, bulldozer, etc.) to strip the overburden. A group of miners could put their resources together and hire a machine from private contractors or equipment hire companies, e.g., PEHCO. Miners' Associations (e.g. REMAs) should facilitate this.

(iii) Manual Hand Drills
Manual breakage of hard rocks can be enhanced by using manual rotating drills, e.g. the Lisheths hand rotary drill, followed by blasting. The drill which is rotated by hand, is supported by a telescopic double tube frame braced with an adjusting screw. The percussion drill utilizes an auger bit to remove the cuttings from the drilled hole. The lifespan of the drill rod is about 3,000m.

(iv) Drill and Breaker
A self-powered drill/breaker with a built in petrol engine has been produced and is highly recommended specifically for open cast operations. The machine has the capacity to drill up to 6m hole lengths with 34mm bits. With fuel consumption of 1.1-1.5 litres per hour and drilling rate of 250-300mm per minute, the 24kg machine is suitable for small operators. Its limitation for underground work is that it has no water line and hence cannot perform wet-drilling. In addition, the use of gasoline in poorly ventilated workings, may be a cause for concern.

(b) Rock Excavators
In most open cast operations rock excavators are widely used for various production tasks including excavations of soft materials, loading of blasted material, etc. Although there are several down-sized designs of the widely known heavy duty mine excavators, the following have been chosen as being suitable for artisanal and small-scale mining;

(1) Micro-Excavator
This is a very small excavator powered by a Honda air-cooled, four stroke single cylinder petrol/diesel engine with breakout force of 1.9 tonnes. It is highly mobile in that it can be towed to site by a vehicle.

(2) Tractor-Mounted Backhole
This is a backhoe version designed for attachment to any tractor with three point linkage and a hydraulic power take-off. It has a bucket breakout force of 1.83 tonnes and a loading capacity of 200kg at maximum extension. This would be the most appropriate excavator for many alluvial operations.

(c) Ventilation Equipment
(1) A small blower manual fan that has already been fabricated at Mgusu is the most appropriate for ventilating underground artisanal workings. However, it needs further research in order to improve its efficiency. An improved drive mechanism for this version

as used in Colombia is given in Priester, et al., 1992. A gasoline engine can also be adapted to drive the blower fan.

(2) Where compressed air is available a small pneumatic fan can be utilized.

(3) An Air-jet Ventilator that is driven by compressed air is very appropriate for ventilating artisanal underground workings. Compressed air blown through a small nozzle drawing additional air into the chamber at a ratio of 1:35. It can be locally made and has a long lifespan with no moving parts.

(d) Water Supply and Drainage

(1) Pneumatic High Pressure Pumps

Where compressed air is available, pneumatic high pressure pumps can be used for drainage of both surface and underground working. Although they are not easy to manufacture locally, they are readily available from mine equipment manufacturers, e.g. ATLAS COPCO.

(2) Tyre Pump

The tyre pump is a simple diaphragm pump that is designed to convey huge quantities of water over a small head. It can be manually driven, or with pedal drive. The design is suitable for alluvial workings which usually moves large volumes of water with small water heads.

(3) Manual drainage systems

Manual drainage systems as practiced now by using a bucket and a rope can be improved by improving the driving mechanism. This calls for further research into utilization of bucket-chain conveyors, water bags, Chinese liberation pumps and other mechanisms used elsewhere.

(e) Supports

(1) Timber supports

They remain the most practical and easy to install by artisanal miners. However, miners education is needed in identification of the right timber for particular conditions, installation procedures, preservation and environmental considerations.

(2) Rock bolts

They can be used to support loose blocks of rock within the strata in the working areas. They can be locally manufactured from most workshops. Their usage however will be limited to those with drilling machines as they must be inserted in a drilled hole.

(f) Lighting

(1) Local gasoline lamps (vibatali)

These should be discouraged from artisanal workings as they have in most cases lead to suffocation accidents. However, professionally designed gasoline lumps with a gasoline

tank, a wick system, a burning chamber isolated with glass and an open wire basket, are widely used worldwide.

(2) Calcium carbide lamps
They are available as both (i) hand lamp and (ii) cap lamps which can be fixed on the helmet.

(3) Compressed Air Lamps
For stationary lighting, e.g. working at the face, compressed air lamps are appropriate. They can be fixed directly to a compressed airline for a drilling machine or pump.

(g) Loading
(1) Mucking Sheets
These are pieces of scrap metal usually 2mxlm by 5mm thick that are laid on the floor before breaking the rock. Manual loading is then made easier as the shovel can scrap the bottom with little friction.

(2) Hand Scraper and Tray
It utilizes a triangular pick with a handle and tray to which the material is gathered. Instead of using a shovel to load small amounts, the scraper is used to gather material on a tray which when filled is emptied into the container. It improves loading efficiency through less work effort.

(3) Cousin Jack Boxes
For steeply inclined vein deposits, a loading box can be constructed to avoid reloading of materials. It utilizes gravity to fill the box which is then opened to load the container. It however requires a well planned mining method with a haulage drift at the bottom of the stope.

(4) Slusher/Scraper Haulage
Scrapers are heavy duty equipment commonly used to scrape material to a particular control point. There are down-sized versions of this equipment that are air-powered and hence convenient for small-scale operations. A complete unit comprises of a prime mover, ropes, return pulley and the scraper. Depending on the operating conditions frame proof or non-frame proof units are supplied. The hauling distance is limited by the drums rope capacity with a typical example being 84m for a 13mm diameter wire rope.

(h) Hauling and Hoisting
(1) Manual Winches
These already exist in most artisanal underground mining areas, e.g. Mgusu and Merelani. However, the current designs are crudely done and inefficient. Further research is required to improve the designs. Windlasses with brake pads are one of the designs of manual winches.

(2) Air Winches

Air winches are compressed-air-powered simple, robust and readily portable equipment. They can be used for both horizontal and vertical haulage. The winch can be easily secured on a floor foundation or on a wall depending on the mode of utilization. It has a fitted brake system for speed control.

(3) Motor Cars

The car chassis upon which the engine clutch, gear differentials and drive axle are still in operation, can be used for hauling. At Merelani, a tractor has been used for this purpose. Indicators for hoisting depth signal, etc. can be attached on a display board. This would require further research to turn it into reality. Designs of rope drums should also be reviewed.

(4) Roadway Haulage

The high cost of acquiring and laying rails, makes track bound haulage inappropriate for artisanal mining. Instead all improvements on haulage should concentrate on trackless haulage. This requires a roadway with properly cleaned, balanced and stable ground so as to reduce friction. Timber boards could be lined at the bottom upon which wheelbarrows and push wagons run. The main trackless hauling equipment include, wheelbarrows or carts and push wagons with rubber wheels.

(5) Man Hoisting

A passenger lifting moving ladder utilizes two pairs of ropes or rods to haul passengers up and down the vertical shaft. It has footboards and handles attached to both ropes at intervals of 3-4m. Up and downward movement is possible through systematic shifting from one pair to the other. The system can be adapted to an inclined shaft through running the ropes on slide boards or roller guides. As miners loose a lot of time moving up and down there is an urgent need for further investigations of this equipment.

(6) Hoist for Small Shafts

This equipment is included here in order to encourage local engineering institutions to research into its design and fabrication. It is currently being produced by an Australian Company, Miner's Den of Victoria, Australia. It contains a steel frame, winding and tipping gear and a ladder extending 14.9m down the shaft. The problem to most artisanal miners is that it is powered by an electric motor. However, there are those who can afford a generator. Apart from being lightweight and portable, it is also easy to fabricate locally.

(i) Blasting

Apart from the main blasting ingredients of explosives and detonators, blasting machines and meters are usually necessary. A small blasting machine with capacity for 25 shots is adequate for artisanal mining operations. The hand operated IDL machine generates up to 130 volts and has a limiting resistance of 1100 ohms. A blasting meter is usually used to test the continuity of the electric connections before firing. The importance of such tests is both for safety and time saving rather than dealing with misfires and tracing of

disconnections. The meters usually have low testing current, e.g., 4mA, so that detonators cannot be accidentally fired by the test current.

(j) Mineral Beneficiation Equipment

(i) Crushing and grinding

Crushing and grinding of hard rock require high energy input. The specific energy requirement for communiting raw ore is heavily dependent on the type of ore, e.g., reef ore may require specific energy exceeding 50 kWh/t. Such high power equipment may not be conducive to the Tanzanian artisanal miner. In order to facilitate the crushing and grinding operations at artisanal level several alternative equipment have been proposed taking into account the remoteness of the mining sites and investment levels of the artisanal miners. The proposed crushing and grinding equipment include:

(1) The See-Saw Crusher

This is a manually driven equipment which can also be driven hydromechanically. it has the capacity of 0.7 - 1.5 Kg/min.

(2) The Chilean Mill

This is applicable for the production of very fine grained product. It can be driven hydromechanically or by animal powered whims. A modern version of the mill is driven by an electric motor in operation with electric supply. It has a high throughput of up to 1.0 tonne per hour.

(3) The stamp mill

A stamp mill can be used as an alternative crushing equipment, it can be driven by hydropower or an internal combustion engine. It can have a throughput capacity of 0.8 - 2.5 tonnes per 24 hours.

(4) The Ball mill

This equipment is usually used for fine grinding. At the artisanal level, manual hand-cranked ball mill with spiral feed chute are recommended. However, ball mills driven by petrol and diesel engines are also available. Ball mills are cumbersome for batch processes but can handle relatively high throughput in comparison, up to 0.5 tonnes/hour with petrol engine which far outweighs the batch process problem. Ball mills driven by petrol engines are commonly used by artisanal miners in the Philippines.

(5) The Jaw Crusher

This is probably the best primary crushing equipment that is also applicable in artisanal mining operations. It is excellent for crushing of hard rock even in mechanized mining. In artisanal mining, the single toggle jaw crusher is common. It may have a feed opening ration of 2:1, e.g., 250x125mm and 400x250mm with a gap setting of 30-70mm. The single toggle crusher may also be used as a secondary crusher for production of 12-20mm maximum size particles. It can be driven by diesel or gasoline engines. The throughput is about 350 kg per hour.

(ii) Classification and Screening

During the site visits it was noted that mainly hand screens and small pans were used for classifying the stones before final separations, (e.g., at Mabuki diamond and matombo ruby mining). In gold mining areas, sacked strakes are used both for classification and separation (concentration). The achieved recovery when using these pieces of equipment is too low considering the small gravel tonnage handled per day. In order to improve screening and classification in artisanal mining operations, the following equipment are suggested:

(1) Application of Rigid Screens

These are screens arranged in series and can perform wet or dry screening. Dry screening is applied for dry coarse grained material and screens must be inclined. The wet screening is conducted in a series of successive stationary screens built in to a sluice or trough (screening gates). Feeding is manual and the operation is semi-continuous. Throughput is as high as 500 kg/hr but is highly dependent on the size of the feed. This design is useful for screening gravel. It is successively applied in artisanal mining areas in Bolivia, e.g., Mina Candalaria Sudlipez Mine, (Priester, 1992).

(2) Vibrating Screens

Vibrating screens are usually mechanized but may also be driven by hydromechanic or manual impact mechanisms. They are very effective and preferable to rigid screens due to higher efficiency, lower space and less water requirements.

(3) Sizing Drums

The sizing drum is a mechanized form of a wet screen in which several screens or perforated plates are arranged so as to form a drum. The drum is rotated by an external belt-drive transmission. The materials move from finer to coarse screens during which the undersized grains are discharged via cones and distributed to the various sorting devices. The drum can be manually operated for small models and is continuous with minimum capacity of 1.0 tonnes per hour.

(4) Cone Classifier

It consists of a set of several settling chambers in the form of inverse pyramids with outlets at the bottom. This classifier is good for beneficiation of fine grained material and is suitable for artisanal mining due to its sturdy construction and low investment costs. The form of driving energy required is the processing water current.

(5) Sluice Box

The sluice box is one of the most commonly used equipment in small-scale operations. It can be used both as a sizing equipment as well as a separating equipment. A simple sluice box is a long open box with one short side open and riffles fitted along the length of the box. Sluice boxes may be made of timber or steel plates depending on the ability of the miners. The feed flows through the riffles leaving heavy minerals trapped at the bottom. The water flow rate should be high enough, e.g., 400 - 800 litres per minute when

recovering heavy minerals from gravels. Sluice boxes are not mechanized and use the energy of flowing water.
A more advanced sluice box is the Bambazonke Concentrator. It is essentially an ordinary sluice box with water supplied by a pump (using a diesel engine) connected to the sluice box. It contains a sieve connected to the feed end to remove large stones. The equipment was in 1990 commissioned at the Lupa Gold Mine in Chunya with successful results.

Sluice boxes are conducive even with consolidated feed containing high clay content, consolidated sediments, feed from abandoned workings, etc. The material is mixed with water in the pit and repeatedly kneaded by using picks while breaking cemented clay fractions before separation in the sluice box.

(iii) Mineral Separation or Sorting
Mineral separation in artisanal mining refers to the reconcentration processes undertaken after screening and classification. The recovered product is the valuable marketable mineral or concentrate. Processes may be gravimetric (density), electromagnetic (magnetic properties), electrostatic (electrical properties) or the chemical metallurgical operation. However, the gravimetric separation is the separation method typically used in artisanal mining. This method is applied where heavy minerals are the valuable mineral source in the raw ore feed as found in most artisanal operations. Some equipment used by (or available to) artisanal miners for final separation of the minerals are the steel pans, sacked strakes, sluice boxes, etc., all of which have low capacities and efficiencies. The following are recommended equipment for artisanal mining application for final separation or sorting.

(l)Jigs
The jig is a device which uses the force of water to separate the heavy minerals from the lighter gang minerals. The simplest of these equipment is the "hand jig" with moving bed operation used for sorting coarse grains. This equipment may be applied for separation of alluvial gold, gemstones, etc. The jig is capable of separating up to 5 - 10 Kg per man-minute. Other jigs include; (a) Hand Piston Jig which is constructed as a double jig box. The movement of the piston creates longitudinal flow of the slurry through the jig thus creating a lateral component. The up and down motion of the slurry results in a faster separation of lighter and heavy particles, (b) Mechanized Piston Jig (Harzer jig) wjiich works analogous to a hand piston jig but equipped with a mechanized drive system. It can be driven by an internal combustion engine via transmission or hydromechanical energy. The throughput capacity is above 1.0 tonnes per hour.

(2) Re-Concentration Sluices
Special designed sluices can be used for reconcentration of heavy minerals. The sluice boxes discussed for classification require high flow rates of water with turbulence in order to wash out the high amount of gravel. Finely ground particles of ore (recovery of heavy minerals from primary ores) and secondary processing of concentrates is usually treated at lower flow rates to avoid losses. For example, Sacked strakes used by gold miners to recover gold concentrate can be improved to a reconcentration sluice box by fixing side

plates of about 0.5 feet high and riffles along its length. Throughput will be higher and losses minimized. In some cases fine gold amalgamation is carried out in sluices by placing mercury in riffle channels. However, mercury losses are very high.

(3) Sorting Tables
These tables are used to separate two or more minerals according to specific gravity by flowing a slurry on it. There are several types of sorting tables already in use by artisanal miners.

The Bumping Table or Concussion Table
It is a flat rectangular longitudinally inclined table. Slurry is flown on the table by pouring it longitudinally on one end. To increase the precision of separation, the material is loosened by pounding on the table surface in the longitudinal direction. Heavy material settles out closer to the feed input point and lighter material remains suspended and is carried out with the float. The table can be driven by hydromechanical drive, internal combustion engine, manual drive or pedal drive.

Other tables
The sweeping table (belt table) and the racking table (tilting table). These tables require no driving energy other than the slurry or processing water. Separating takes place along the length of the belt with heavy minerals settling close to the feed point, then the middling and lastly the tailings. Fully mechanized tables are the vibrating tables which can be operated by an internal combustion engine.

Diamond concentrate is usually treated on slightly different tables. The final concentrate is washed across a "Grease Table" to which the diamonds stick while waste gangue materials wash off. The grease is periodically scraped off and melted to recover the diamonds.

(4) Spiral Concentrators
The spiral concentrator is a sorting device primarily based on vertical separation according to densities. The best known spiral concentrator is the "Humphrey Spiral". It consists of helical sluices with four to six turns. The sorting effect results into heavier particles sinking to the bottom of the spiral sluice section where friction and drag act to slow the material down. The lighter weight particles move to the outside and are carried away by the faster, more dilute pulp stream. The equipment is good for medium particle size minerals (0.074-2.0mm), The capacity varies from 0.5 - 12.0 tonnes per hour depending on dimension of channels (spiral sluice) and grain size of the feed.

(5) Amalgam Distillation Retorts
A distillation retort is a simple piece of equipment assembled with a closed crucible connected to a condenser. It is designed so that mercury from the gold-mercury amalgam evaporates off due to its low boiling point when heated, leaving the gold metal in the crucible. The mercury vapour condenses as it goes through the condenser and collects as droplets in the catchment vessel containing water to prevent any further evaporation. There

are three types regarded as affordable to most artisanal miners. The first is that designed by the Institute of Production Innovation (IPI) at the University of Dar-es-Salaam. The air cooled retort has a cast iron bottom cap and mild steel condenser pipe and cooling fins. The 2.4 kg weighing retort (including condenser) has already been tested in the field with encouraging results. Mercury recovery of up to 99.6% has been recorded. The second affordable retort is that given by Blowers, 1982, which uses a piece of an 80mm pipe welded at one end and screws threaded on the other hand. Another piece of an 80mm pipe is welded with a 12-20mm bent pipe and threaded internally. The Intermediate Technology Development Group (ITDG), provides us with a third retort design. It is based on pipe fittings that can be picked from an hardware store. It utilizes a 6mm galvanized iron pipe threaded on one end, a 6-13mm galvanized iron reducing bush, a 13-38mm galvanized iron reducer and a 38mm galvanized iron plug. Whilst the two last designs have not been tested here, they are widely used in other countries, e.g., Papua New Guinea.

(k) Safety Equipment

The chaotic nature of most small-scale operations, the lack of capital and technical know-how, exposes small miners to more hazardous working conditions in comparison to their counterparts in the more formal medium to large scale operations. As such, in order to improve productivity, reduce stoppages and shutdowns and improve overall efficiency, investment in safety measures and equipment should be regarded as essential. Safety equipment regarded as essential for artisanal miners are as follows: (i) Safety Helmets; (ii) Safety Boots; (iii) Cap Lamps;
(iv) Gas Detectors, (Hand held units, e.g., for Oxygen deficiency, Methane, Carbon-Monoxide, etc.);
Other safety equipment which should be used as need arises include: (v) Ear Protectors; (vi) Safety Goggles; (vii) Respirators;
(viii) Body Harnesses and Safety Slings.
However, before we can insist or enact laws for the usage of these equipment as it is in formal mines, we must ensure availability and sensitization of miners on the advantages of their usage.

APPENDIX II

Energy Sources

One of the major constraints for improving artisanal miners' working conditions, e.g., introducing some form of mechanization, is the source of energy. Although there are manually operated equipment in use that can be improved to increase efficiency, the majority need another source of energy to drive them. The inconsistency of winds in most mining areas make it an unreliable source and wind operated equipment, e.g., pumps, are expensive compared to those operated by other sources, e.g., diesel operated. Solar energy has a future and is very competitive for the remote artisanal mining areas. Further research should be directed in this area. The small hydropower utilization as found in South America is not practical here given the water requirements in most artisanal mining areas. Given the above conditions and the lack of grid connected electricity, the following are proposed as practical choices.

(a) Bicycle/Pedal Drive

Simple artisanal mining equipment, e.g., blowers, grinders, percussion jigs, tire pump, concussion table, etc., can be efficiently driven by using pedals or a bicycle drive system. The system can be applied to provide continually rotating low-power movements. Suitable equipment for this drive mechanism should have power requirements of less than 100W.

(b) Animal-Powered Whims

Up to the nineteenth century, animals were widely used in Europe to provide power especially in agriculture. The application in mining and mineral beneficiation has been in driving machines requiring high torque and low RPM. Example application areas include shaft haulage, water pumping, grinding machines (e.g., ball and roller mills), concussion tables, etc. Commonly used animals include horses, donkeys, mules and oxen. Machines with power requirements up to 1000W can be driven by animal powered-whims. An animal attached to the end of the lever walks in a circle and thus rotating the arm which in turn drives the machine.

(c) Water Wheels

The requirement of water as the driving media for the gravity machines do not make them very attractive for most of our artisanal mining sites. However, their high efficiencies, easiness in construction locally, simple hydraulic design and construction among other advantages, puts them in an area for further investigations. The wheels can be used for production of electric energy and mechanical drive for machinery. However, the generated energy cannot be transmitted long distances a requirement which forces both the producer and the consumer to be within the location of the water energy source.

(d) Internal Combustion Engines

The use of internal combustion engines in artisanal mining areas is already spreading in this country, e.g., at Merelani in Arusha. The smaller units like those found at Merelani are used as direct drive systems. On the other hand, the larger units drive generators for the

production of electric energy. DEMCO Mine, a formal small-scale mine in Chunya, has installed a generator driven by an diesel internal combustion engine. The wide capacity range, 2-100 kW, gives a wide choice to the user. Although the investment costs are usually low, operating costs are high. In addition, despite the attractiveness of these machines, the lack of direct supply channels leads to frustrations to most miners.

(e) Compressors

Compressors are used to generate compressed air which is required by pneumatic operated equipment, e.g., mine fans, drilling machines, pumps, etc. A compressor can be driven by an electric motor, diesel engine or a hydromechanical system. They are an essential tool to all mining operations. However, in most artisanal operations with compressors in this country, they are under-utilized despite their high investment and operating costs. This is usually as a result of lack of technical knowledge and support required during equipment selection. In Merelani for example, a compressor with 750 cubic feet per minute (cfm) capacity was found running one drilling machine with a second hose connection being use to ventilate the mine. Most jackhammers like those used by artisanal miners at Merelani require less than 150 cfm. However, this is an equipment every miner all around the country dreams of owning for obvious reasons.

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